LOUISIANA DEPARTMENT OF WILDLIFE & FISHERIES

OFFICE OF FISHERIES
INLAND FISHERIES SECTION

PART VI -B

WATERBODY MANAGEMENT PLAN SERIES

VERNON LAKE

WATERBODY EVALUATION & RECOMMENDATIONS

CHRONOLOGY

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TABLE OF CONTENTS

WATERBODY EVALUATION

STRATEGY STATEMENT

Recreational

Largemouth bass (LMB) are managed to provide anglers with the greatest opportunity to catch fish of greater than average size. Frequent introductions of Florida largemouth bass (FLMB) into the population provide the basis for incorporating certain genetic traits that are more likely to produce large bass. Sunfish, crappie and catfish are managed to provide a sustainable population while providing anglers the opportunity to catch and harvest numbers of fish.

Commercial

The physical characteristics of Vernon Lake do not support large rough fish species that normally comprise a commercial fishery. Therefore, the commercial fishery is limited to catfish species, including channel catfish (*Ictalurus punctatus*), blue catfish (*I. furcatus)*, flathead catfish (*Pylodictis olivaris*), and the bullhead catfishes (*Ameiurus* spp.). The existing prohibition on certain commercial fishing gears follows the recreational strategy chosen for many of our popular inland reservoirs, emphasizing recreational fisheries for bass and crappies. Catfish are managed to provide a sustainable population while providing anglers the opportunity to harvest numbers of fish. There is a robust population of channel catfish in Vernon Lake which could withstand increased harvest in order to provide a more balanced game fish community within the lake. Harvest of these catfishes should be promoted to potential anglers and trotliners, with benefits to other recreational fish species emphasized.

Species of Special Concern

No threatened or endangered fish species are found in this waterbody. However, two species of conservation concern, the western sand darter (*Ammocrypta clara*) and the Sabine shiner (*Notropis sabinae*) (Louisiana Comprehensive Wildlife Action Plan Louisiana Natural Heritage Program, 2005) are monitored in standardized sampling activities to determine if viable populations exist in the reservoir. Only the Sabine shiner has been collected by LDWF, with the last specimen collected in 1996.

EXISTING HARVEST REGULATIONS

Recreational

Removal of Quality Largemouth Bass Lake Designation

April 20, 2014: The 14 – 17 inch protective slot limit for bass was removed. From this date forward, statewide harvest regulations for black bass (10 per day creel and no minimum length limit) are in effect for Vernon Lake. Statewide regulations apply to all fish species. The recreational fishing regulations may be viewed at the following link:

http://www.wlf.louisiana.gov/fishing/regulations

Commercial

Statewide regulations apply to all fish species except that the use of gill nets, trammel nets, fish seines and hoop nets are prohibited in Vernon Lake as per Louisiana RS 76:103. The commercial fishing regulations may be viewed at the link below:

http://www.wlf.louisiana.gov/fishing/regulations

SPECIES EVALUATION

Recreational

Largemouth bass

Electrofishing is the most commonly used sampling technique to assess LMB relative abundance (catch per unit effort = CPUE) and size distribution. Data collected during spring and fall electrofishing are used to describe population trends, age composition, growth rate, mortality rate and the genetic composition of a LMB population.

Largemouth bass size distribution, relative weight, and relative abundance

Largemouth bass comprise 80 to 90% of black basses captured in Vernon Lake samples. While size groups up to 24 inches TL are represented, the majority of largemouth bass fall between 7 and 11 inches TL (Figure 1). This trend was also evident in results from the 2010-2012 LMB population study, where the majority of LMB collected were less than 14" TL (Appendix II, Figure 1). This is believed to be partially from gear bias (electrofishing) and lack of harvest. Relative weights for all but the largest inch groups are good (above 80).

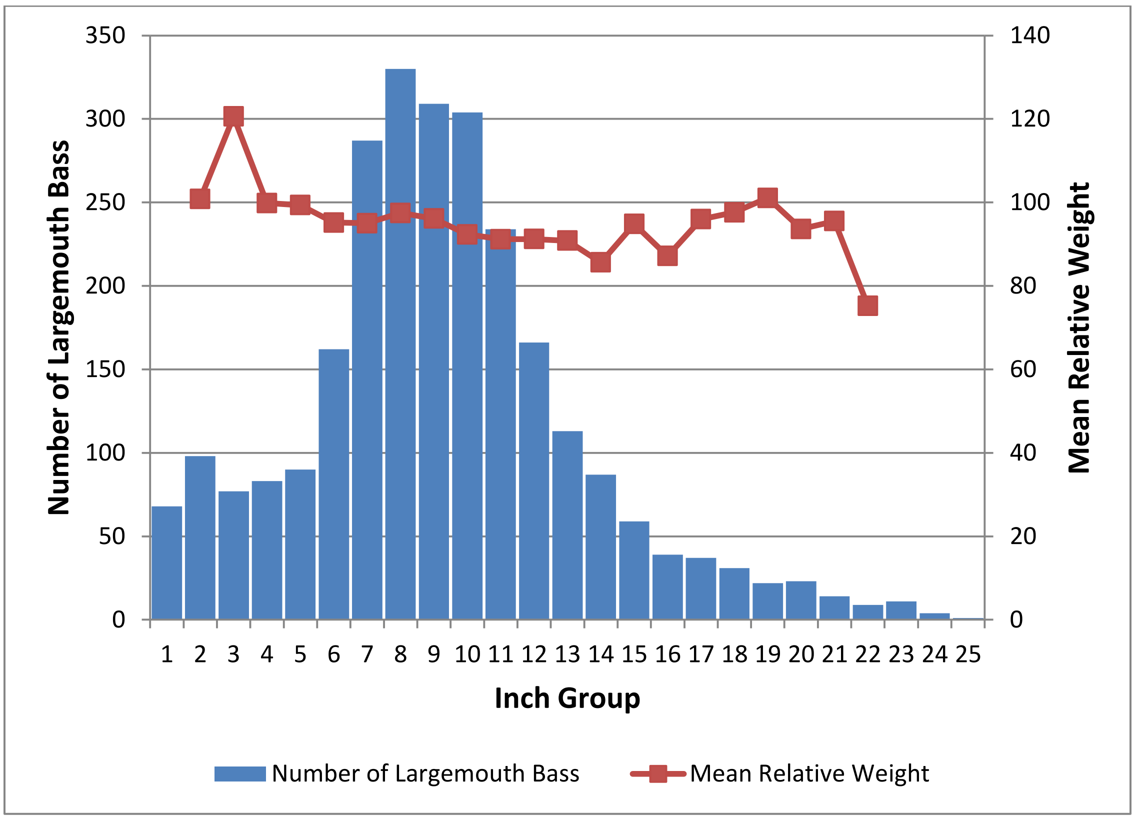

Figure 1. Size distribution (inch groups) and mean Wr by inch group of largemouth bass collected from Vernon lake from all gear types for all seasons from 2000-2014 (n=2,658). Mean Wr calculated from fall electrofishing samples only (n=1,078).

The fall electrofishing catch rate for Vernon Lake usually falls in a range from 40 to 90 bass/hour. Due to annual recruitment variability, significant variability is typical for sub-stock catch rates (Figure 2). The increase in sub-stock and stock-size LMB CPUE from spring 2010 (17.3) to fall 2010 (74.5) indicates the 2009 drawdown increased spawning success and recruitment in 2010 (Figures 2 and 3). The same pattern is also seen in sub-stock catch rates in 1996 and 1999 samples following fall/winter drawdowns. While none of the discussed drawdowns were initiated for fisheries management, benefits to the fishery were seen in the form of increased recruitment.

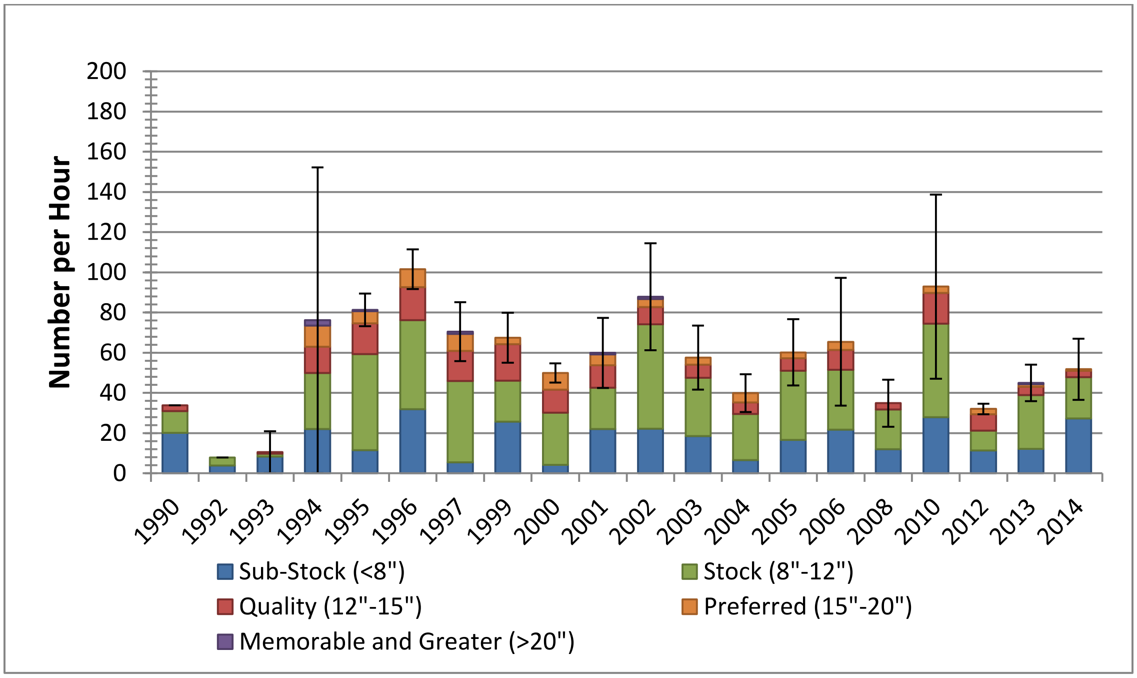

Figure 2. Mean CPUE (± SE) for largemouth bass by size class from standardized fall electrofishing samples 1990-2014 for Vernon Lake, LA. Error bars represent standard error of total mean CPUE.

Relative abundance results from spring electrofishing samples show relatively stable catch rates of preferred-size (15”-20”) LMB over time (Figure 3). This stability is also reflected in the relative stock density for preferred-sized (≥15”) fish (RSD_{15} from fall electrofishing results since 1994 (Figure 4). While these results indicate a stable population of bass larger than 15” TL, results from the 2010-2012 population assessment show that Vernon Lake has fewer fish in this size range relative to other lakes across the state (Appendix II, Table 3). Increased recruitment in 2010 may have influenced the assessment as variable recruitment can bias size structure indices (Neumann et al. 2012). While this stable population of preferred largemouth bass may be due to a combination of several factors (natural population stability, Florida bass stockings, and/or the implementation of the 14” - 17" protected slot regulation), creel survey data indicating relatively low fishing pressure and harvest rates make the last factor unlikely (See Creel Surveys below).

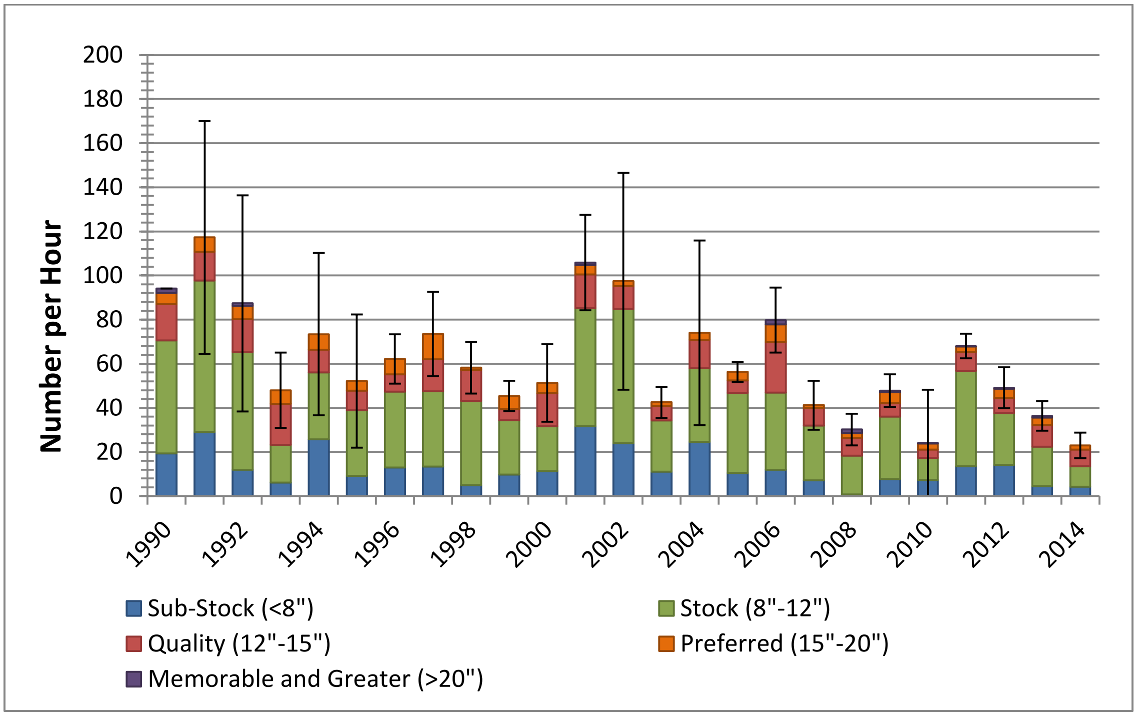

Figure 3. Mean CPUE (+ SE) for largemouth bass by size class from standardized spring electrofishing samples 1990-2014 for Vernon Lake, LA. Error bars represent standard error of total mean CPUE.

Size structure indices

Proportional stock density (PSD) and relative stock density (RSD) are indices used to numerically describe length-frequency data (Anderson and Neumann 1996). Proportional stock density compares the number of fish of quality size (greater than 12 inches for largemouth bass) to the number of bass of stock size (greater than 8 inches in length), and is calculated by the formula:

$$\text{PSD} = \frac{\text{Number of bass} \geq 12 \text{ inches}}{\text{Number of bass} \geq 8 \text{ inches}} \times 100$$

PSD is expressed as a percentage. A fish population with a high PSD consists mainly of larger individuals. A population with a low PSD consists mainly of smaller fish. A value between 40 and 70 generally indicates a balanced bass population. In Vernon Lake, PSD values are usually below 40 in both fall and spring sampling and have never been above 61 (Figures 4 and 5). This trend suggests that the bass population often has an over-abundance of fish less than 12 inches and that the protected slot limit did not accomplish its intended purpose of removing excess smaller fish. This may be attributable to lack of sufficient angler effort, or that the regulation is acting as an effective 17” minimum length limit (see creel survey section). The 2010-2012 population assessment indicates that the LMB population/fishery characteristics of Vernon Lake (moderate growth rate, moderate mortality rate, high recruitment variability/high catch and release rates) were not conducive to a protected slot limit and that the regulation had minor influence on the LMB population (Appendix II**).**

Relative stock density (RSD_{15}) is the percentage of largemouth bass in a stock (fish over 8 inches) that are 15 inches TL or longer, and is calculated by the formula:

$$RSD_{15} = \frac{\text{Number of bass} \geq 15 \text{ inches}}{\text{Number of bass} \geq 8 \text{ inches}} \quad X\ 100$$

An RSD_{15} value between 10 and 40 indicates a balanced bass population, while values between 30 and 60 indicate a higher abundance of larger fish. The RSD_{15} values generated from fall electrofishing results (Figure 4) are generally at or above 10, but never exceed 30. The results for 2013 and 2014 show a downward trend, suggesting an unbalanced population. The RSD_{15} values generated from spring electrofishing results are usually greater than 10, except for the period from 2001 through 2005 (Figure 5). The values are also never greater than 20 in any given year. Removal of the slot limit in early 2014 may improve both spring and fall RSD_{15} numbers over time. While the PSD results are indicative of a preponderance of smaller bass, the RSD_{15} results are indicating a balanced size structure in most years. This discrepancy may be a result of the relatively stable catch rates of preferred-size fish previously discussed. These RSD results are of concern considering the management objective is to produce more, larger LMB. Since no RSD_{15} value is above 30, management objectives were not achieved. The mean RSD_{15} (i.e., PSD-P) value calculated during the 2010-2012 assessment (8.7) ranked 2nd to last among evaluated lakes (Appendix II, Table 3). While this value may have been biased downward by increased recruitment following the 2009 drawdown, it matches historical RSD_{15} values calculated since the implementation of the slot limit.

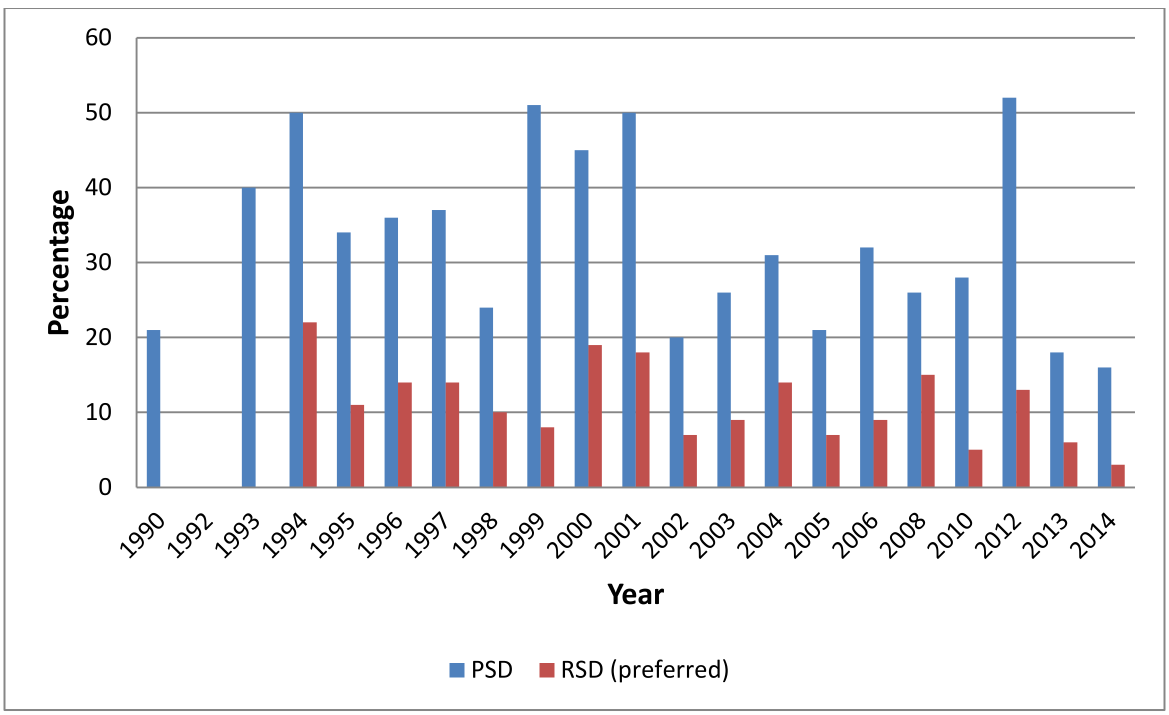

Figure 4. Proportional stock density and relative stock density (preferred) for largemouth bass on Vernon Lake, LA, from fall electrofishing results, 1990 – 2014.

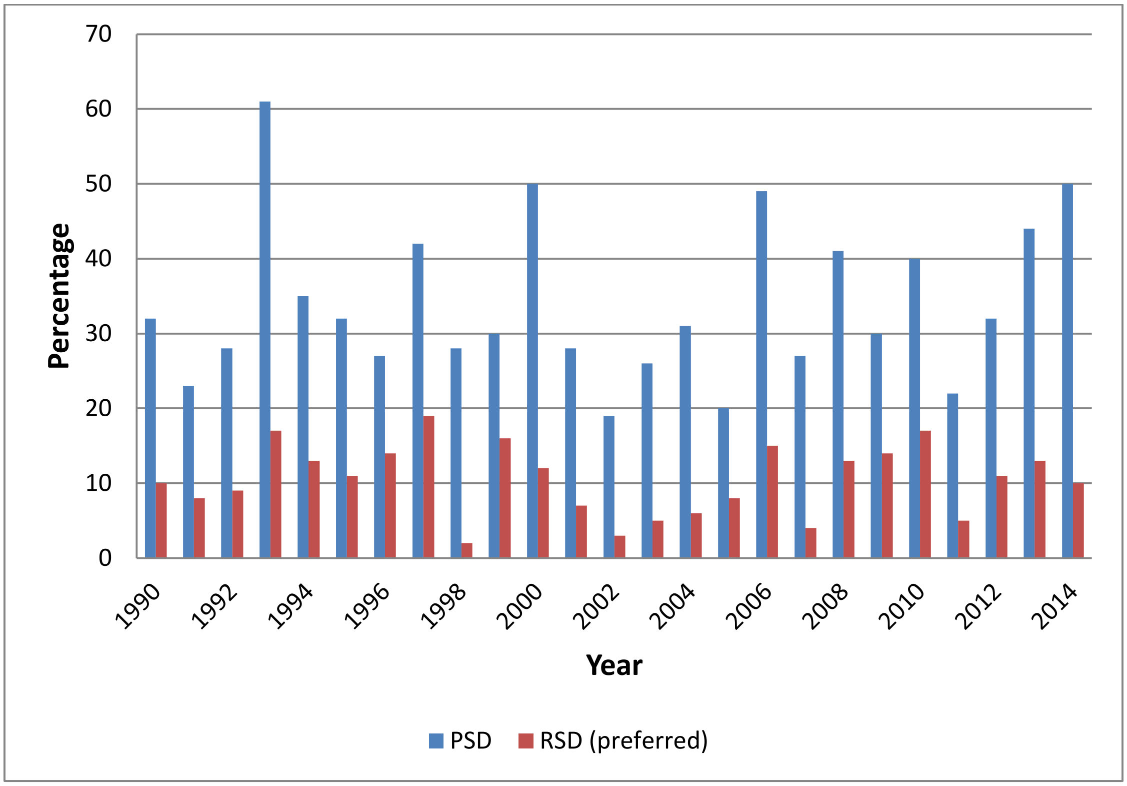

Figure 5. Proportional stock density and relative stock density (preferred) for LMB on Vernon Lake, LA from spring electrofishing results, 1990 – 2014.

Age and growth

Age and growth studies on Vernon Lake during 2005-2008 showed largemouth bass with a truncated age structure (ages 1 – 6), with length-at-age similar to the statewide average until age 6 (Figure 6). While age 6 bass are below the Louisiana average length, the state average is within the 95% confidence interval for Vernon Lake. This indicates these differences may be attributable to small sample sizes of age 6 fish from Vernon Lake.

When compared to other LMB populations assessed in Louisiana during 2010-2012, Vernon Lake LMB exhibited moderate growth rates, with mean age required to reach stock-, quality-, and preferred-size classes (1.2, 2.2, and 3.4 years, respectively) consistently ranked seventh among the waterbodies sampled (Appendix II, Table 2). The maximum LMB length observed in the Vernon Lake assessment was 23 inches TL and the maximum age recorded was 10 years (Appendix II, Table 1).

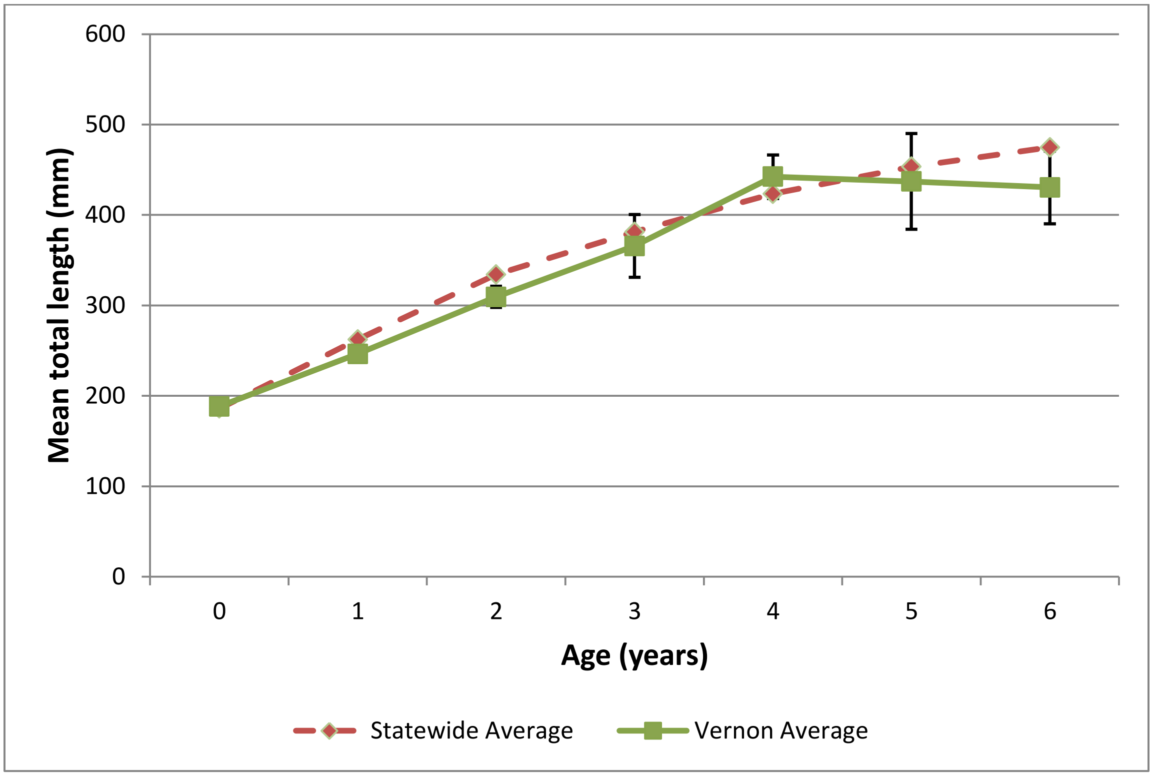

Figure 6. Mean length-at-capture by age class for largemouth bass collected during fall electrofishing samples for the years 2005-2008 from Vernon Lake, LA (n=137). Error bars represent 95% confidence intervals.

Largemouth bass reproduction

Largemouth bass reproduction based on seine haul captures of young-of-the-year (YOY), was relatively high from 1997 to 2003 (Figure 7). From 2004 to 2010, reproduction was lower, but annual variability was similar (± 2 fingerlings/haul).

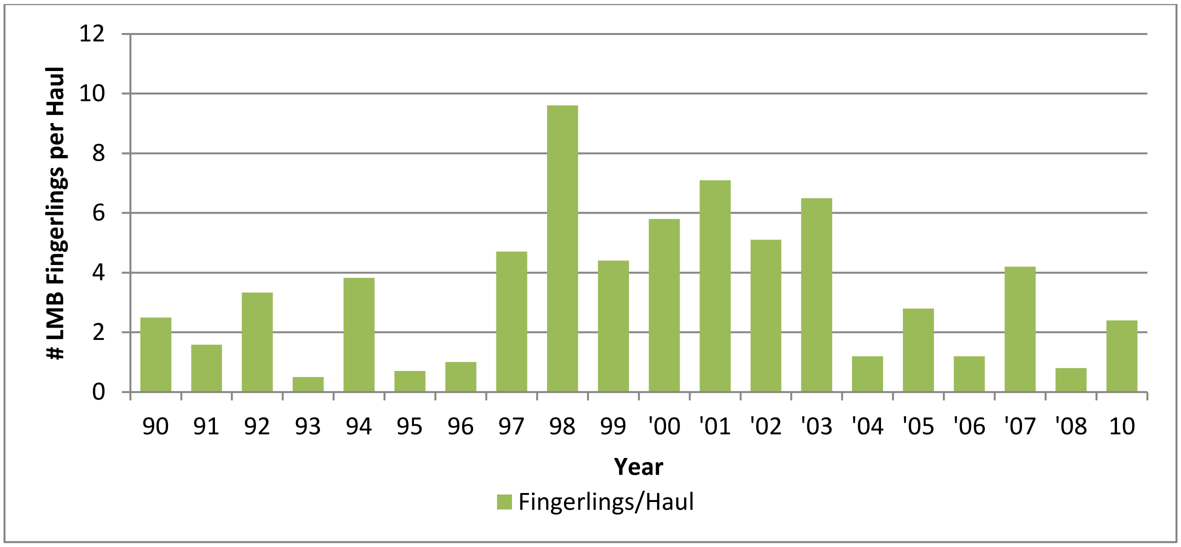

Figure 7. Annual catch per unit effort (fingerlings/seine haul) for YOY largemouth bass from Vernon Lake, LA, 1990-2010.

In 2011, LDWF discontinued the use of seine samples to determine YOY abundance estimates. Recruitment success can be monitored by examining changes in LMB sub-stock relative abundance from spring to fall of a given year. In 2013, catch rates (bass/hour) of sub-stock LMB increased from 4.6 (spring) to 12.1 (fall), indicating successful reproduction (Figures 2 and 3). If growth rates are high enough that YOY bass are fully recruited to the stock (>8") when fall electrofishing occurs, this methodology may underestimate spawning success.

Largemouth bass genetics

Electrophoretic analysis of liver tissue is used to determine the percent of the Florida largemouth bass (FLMB) genome present in Vernon Reservoir (Table 1). In a sample of 30 bass collected in the spring of 1989, two Florida bass and five Florida X northern hybrids were found (23.4% total FLMB influence). This was the first genetic analysis of the LMB population in Vernon Reservoir. LDWF had not stocked FLMB into the lake. Largemouth bass were again genetically analyzed in 1995 after stocking approximately 1,088,036 FLMB fingerlings. Thirty three bass were collected by electrofishing and total FLMB influence was 12%. After additional stockings of approximately 832,933 fingerling and adult FLMB into Vernon Reservoir, the total Florida genome influence was 47% (electrofishing and gill net samples combined) in 2004 (Table 1). While only eight bass were sampled in 2005, the Florida genome was expressed in 50% of the samples. Since these samples were larger fish collected in gill nets, this suggests that there are proportionately more large fish with the Florida gene relative to the population as a whole. From 2010-2012, total mean Florida influence was 32.6%. This may be a more accurate reflection of total FLMB influence in Vernon Lake due to increased sample size during those years. The mean FLMB influence present in bass 17 inches TL and larger from 2010-2012 was 54.3%, almost twice the overall influence in the population. This again indicates that the FLMB genome is expressed at a higher rate among larger fish in Vernon Lake.

Table 1. Genetic analyses for largemouth bass from Vernon Lake, LA, 1989 – 2012.

Genetics of largemouth bass in Vernon Reservoir					
Year	Number Sampled	Northern	Florida	Hybrid	Florida Influence
1989	30	76.7%	6.7%	16.7%	23.4%
1995	33	88%	3%	9%	12%
2004	34	53%	15%	32%	47%
2005	8	50%	0	50%	50%
2007	51	49%	16%	35%	51%
2008	34	82%	0%	18%	18%
2010	95	74%	3%	23%	26%
2011	118	62%	13.5%	24.5%	38%
2012	124	66.1%	11.3%	22.6%	33.9%

Spotted bass

The smaller spotted bass comprises 10% to 20% of the total population of black bass in Vernon Reservoir. The number of spotted bass collected during sampling efforts varies depending upon season and year-class strength. They are most common in the lower reaches of the reservoir along the face of the dam, where the predominant habitat is gravel, rip-rap, and course sand.

Forage

Forage availability for bass and crappie is typically measured directly through electrofishing and indirectly through measurement of body condition or relative weight of bass and crappie. Threadfin shad (*Dorosoma petenense*) and sunfishes (*Lepomis* spp.) comprise the majority of the forage base in Vernon Lake (Figure 8). The successful introduction of threadfin shad into Vernon Reservoir in 1988 has greatly benefited sport fisheries. While gizzard shad (*D. cepedianum*) are abundant in the lake, forage-sized fish (< 6" TL) are relatively less abundant than similar-sized threadfin shad. Therefore, gizzard shad are only available as forage for a short period of time. LDWF forage sampling is not specifically designed to capture shad species; therefore shad abundance may actually be under-represented in some years.

Lepomis, predominantly bluegill (*L. macrochirus*) and longear (*L. megalotis*), are also important forage items for largemouth bass. Minnow species include freshwater silversides (*Labidesthes sicculus*), bullhead minnows (*Pimephales* spp.) and blacktail shiners (*Cyprinella venusta*).

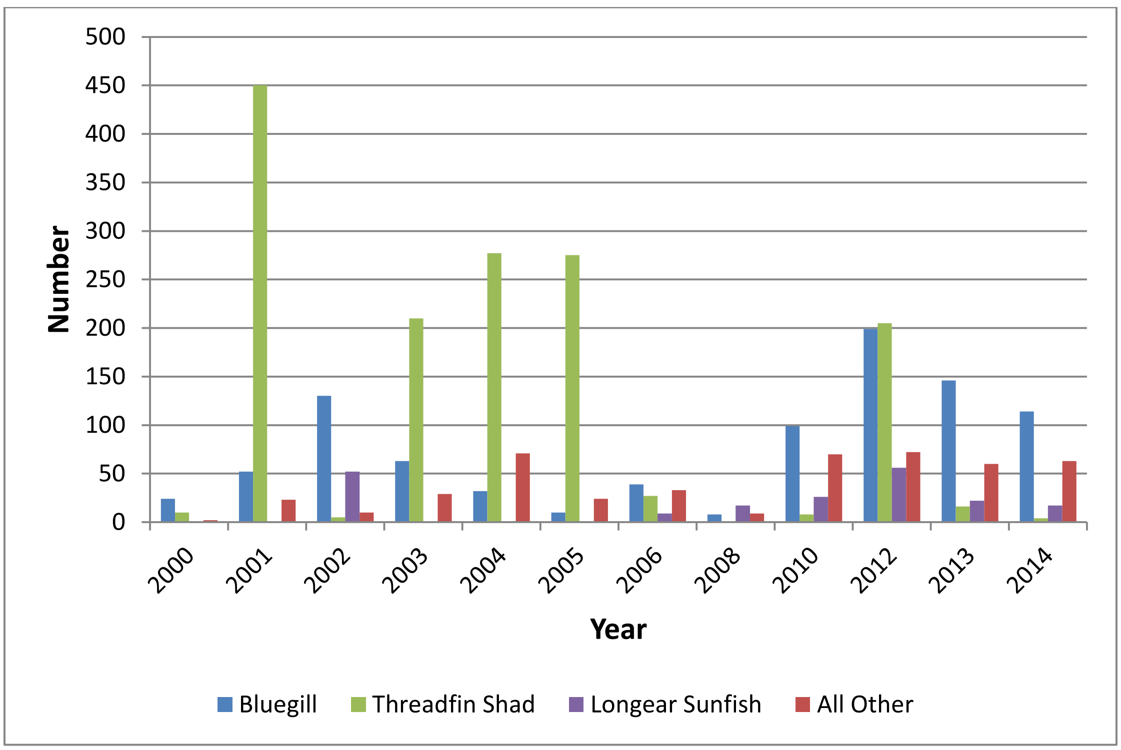

Figure 8. Number of bluegill, threadfin shad, longear sunfish, and all other forage species less than 6 inches TL captured in standardized fall forage electrofishing samples from 2000-2014 on Vernon Lake, LA.

Crappie

Lead net Survey Results

Historically, black crappie (*Pomoxis nigromaculatus*) was the more abundant crappie species (Figure 15). However, results from lead net sampling from 2008 to 2011 indicate that white crappies (*P. annularis*) are more abundant (Figure 9; Appendix III, Table 1). This shift in species composition may be attributed to increased turbidity in Vernon Lake from 2007 to 2009 (Figure 16). White crappies are more abundant than black crappies in habitats with higher turbidities. In 2011, following a decrease in turbidity, black crappies made up approximately 40% of the sample (Appendix III, Table 1). If water clarity remains high, we should expect an equal abundance of species or a return to black crappie being the prevalent species.

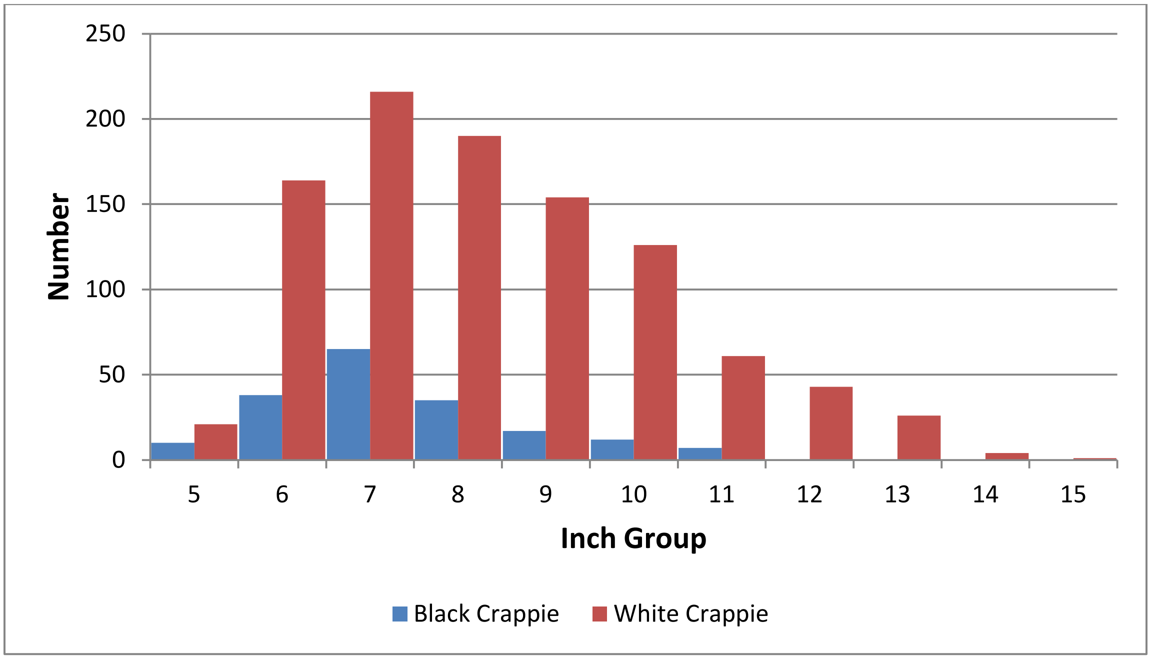

Figure 9. Black crappie (n=184) and white crappie (n=1,006) size distributions (inch groups) on Vernon Lake, LA, generated from standardized lead net results 2008-2011.

Crappie age and growth analysis indicates white crappie reach 10 inches TL in 2.5 years on average (Figure 10). The growth rate during the crappie population assessment from 2009-2011 was very similar (Appendix III, Figure 2). However, individual crappie in Vernon Lake showed highly variable growth rates with 1.5 year old fish ranging in size from 4 to 11 inches, ranking Vernon Lake last in crappie growth rates compared to the other 7 lakes sampled during this same time frame (Appendix III, Table 3). Because the majority of the fish sampled for age and growth were captured by lead nets, age 0+ crappies are not represented due to this gear's size selectivity. Black crappie were not analyzed due to small sample sizes (n=28) from 2008-2009.

The population assessment of crappie in Vernon Lake (Appendix III) reflects a slow growing population that has highly variable recruitment and low relative weights. Given the less than desirable crappie population characteristics, the current regulations are appropriate.

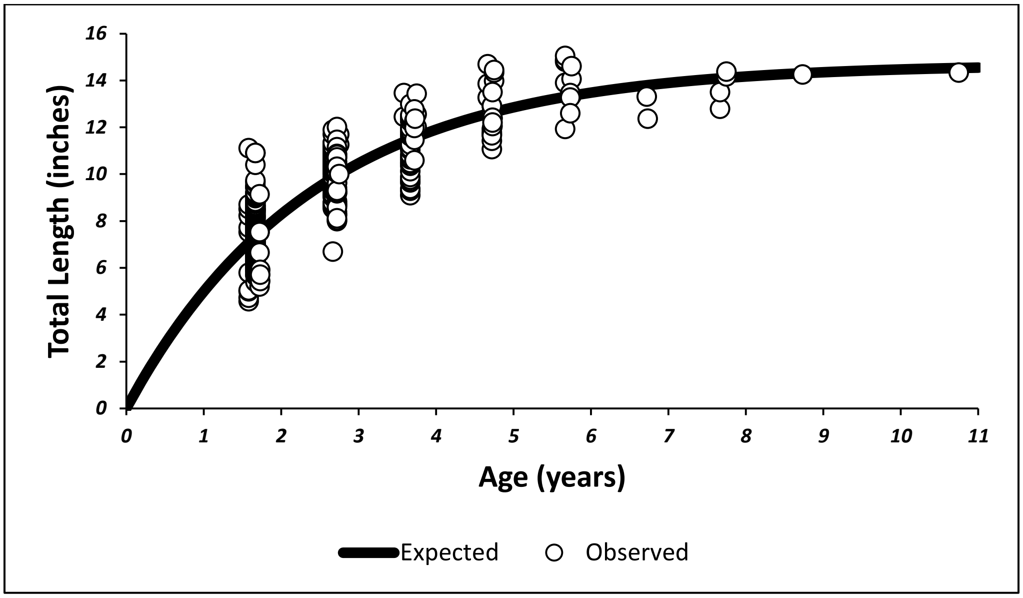

Figure 10. The observed and predicted growth for white crappie from Vernon Lake for 2008-2009, all gears combined (n=447).

Gill Net Survey Results

Gill net sampling is used to collect large bass and other large fish species. Results are reported in pounds per net-night with a net-night defined as 100' of net fished for 12 hours. Largemouth bass represent a significant portion of total pounds captured and were the predominant species from 2002 to 2006 (Figure 11). LMB catch rates in most years ranged from 0.8 to 1.6 lbs/net-night. However, no LMB were captured in 2000. This indicates a significant presence of larger bass that may be under represented in standardized electrofishing.

Catfish are commonly collected in gill nets. Flathead catfish are generally the most abundant by weight (Figure 11). Since 2005, no blue catfish have been collected in gill nets. During the same time period, channel catfish abundance has increased. The highest catch rate of channel catfish and flathead catfish occurred in 2007 with 1.85 and 1.86 lbs/net-night, respectively.

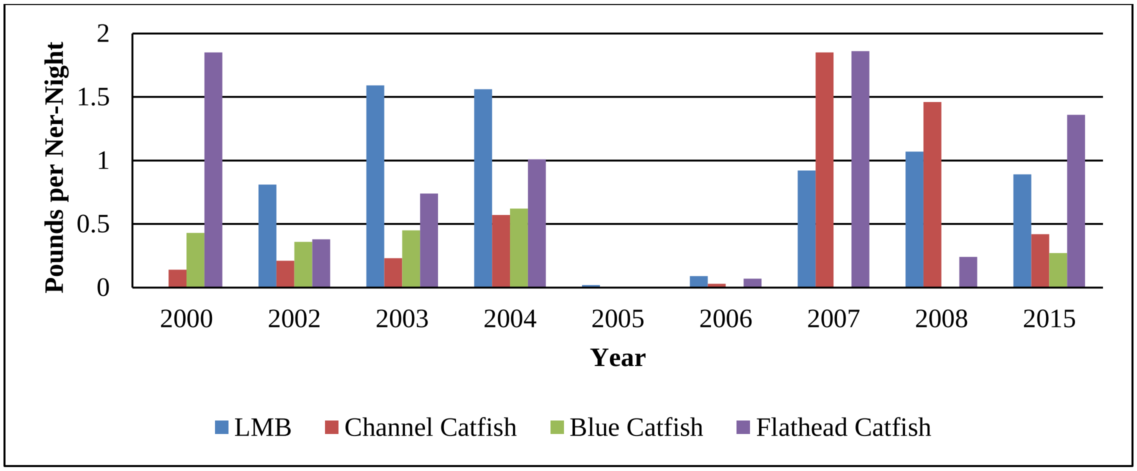

Figure 11. Annual catch per unit effort (pounds per net-night) of largemouth bass, channel catfish, blue catfish, and flathead catfish captured in LDWF standardized gill net sampling in Vernon Lake, LA, from 2000-2015.

Biomass (Rotenone) Surveys

Total standing crop of fish in Lake Vernon from 1967 until 1990 averaged 75 lbs/acre (Figure 12). Total standing crop in 1990 was slightly higher than the long-term average or 77.55 lbs/acre. Peak production years for total standing crop was in 1970 (129 lbs/acre) and 1989 (124 lbs/acre). The predominant shad species from all rotenone samples was gizzard shad (Figure 13), while the predominant *Lepomis* spp. was bluegill and redear (Figure 14). Best overall production occurred in 1974 when 56 lbs. of game fish per acre was noted (Figure 15).

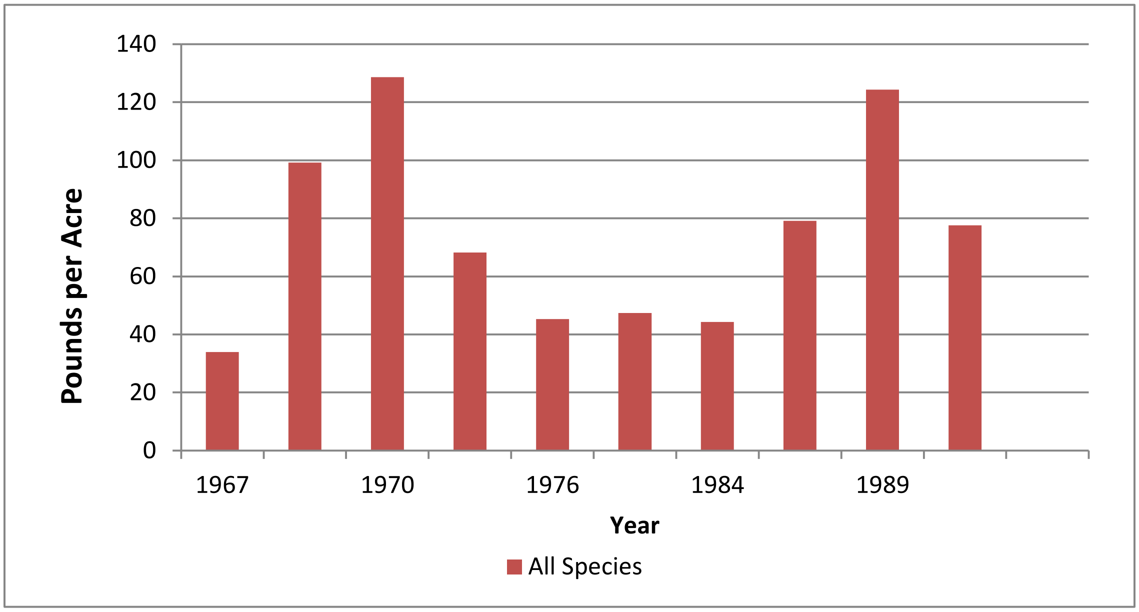

Figure 12. Total standing crop estimates (biomass in lbs/acre) from standardized rotenone samples for Vernon Lake, LA, from 1967-1990.

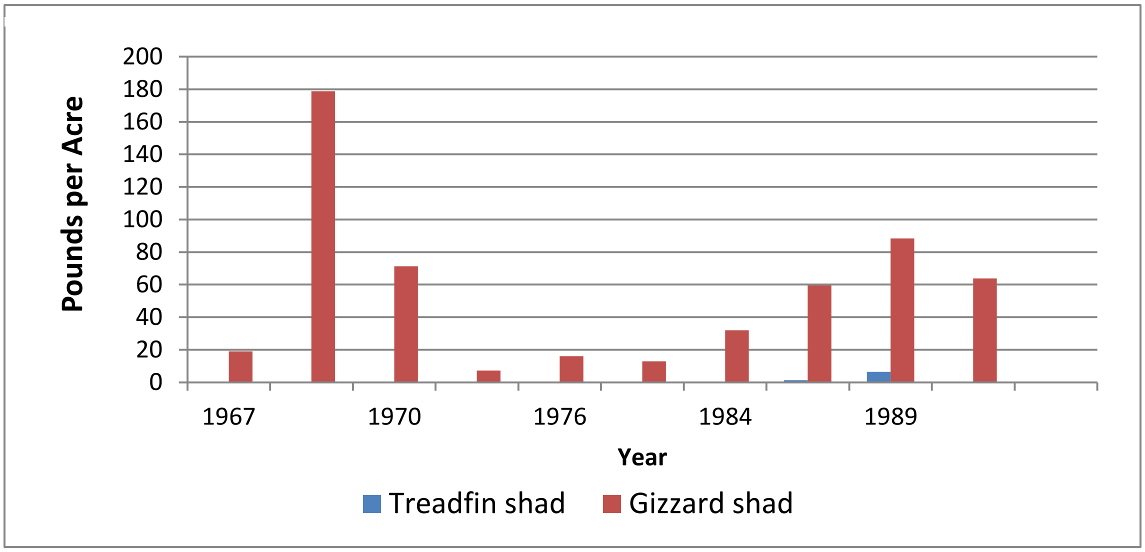

Figure 13. Standing crop estimates (biomass in lbs/acre) of shad (*Dorosoma* spp.) from standardized rotenone samples for Vernon Lake, LA, from 1967-1990.

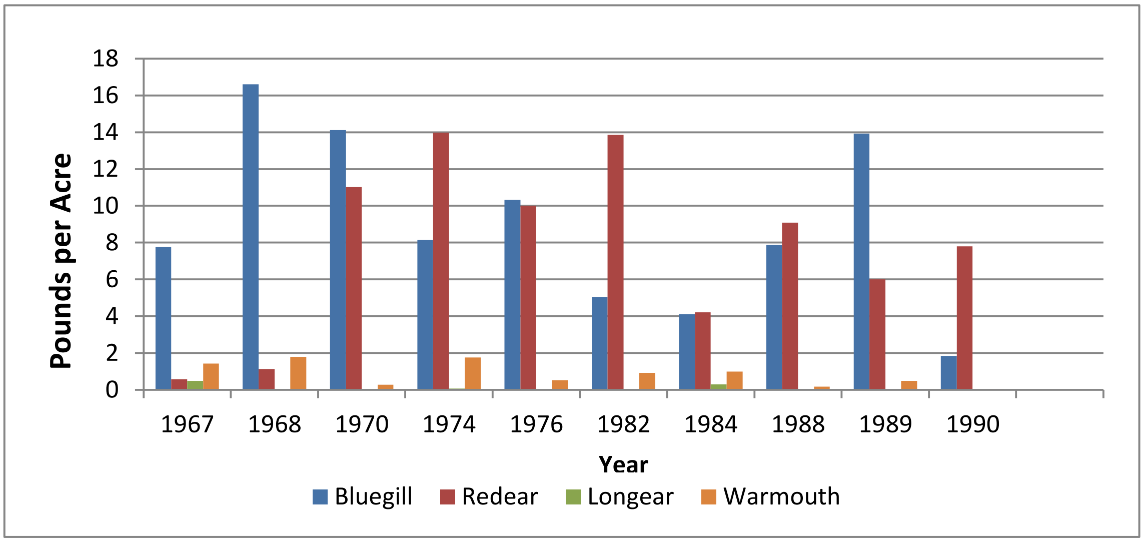

Figure 14. Standing crop estimates (biomass in lbs/acre) of sunfishes (*Lepomis* spp.) from standardized rotenone samples for Vernon Lake, LA, from 1967-1990.

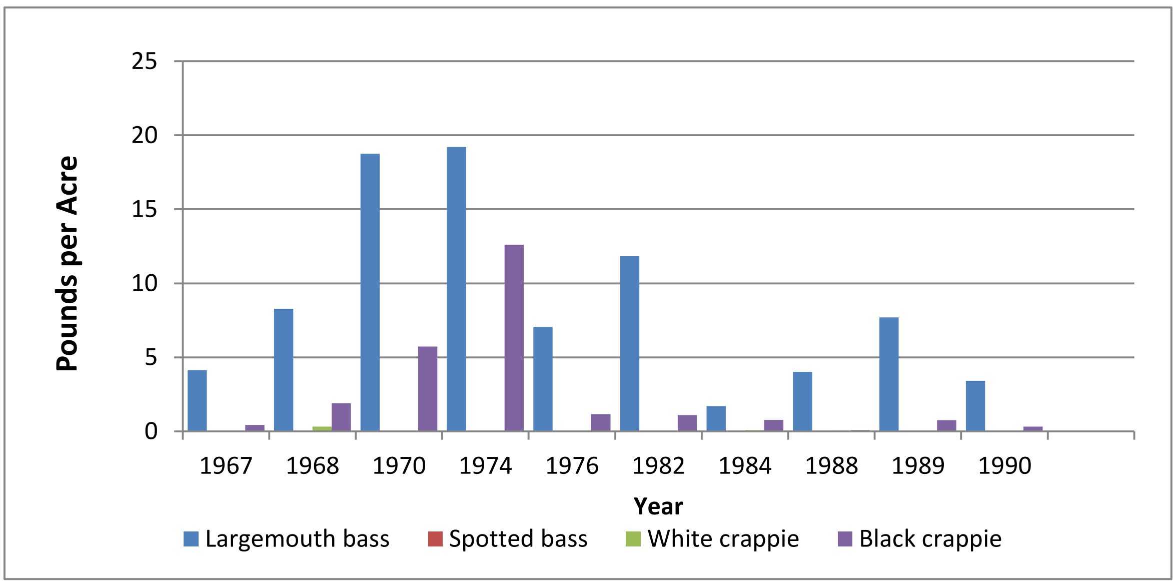

Figure 15. Standing crop estimates (biomass in lbs/acre) for basses (*Micropterus* spp.) and crappies (*Pomoxis* spp.) from standardized rotenone samples for Vernon Lake, LA, from 1967-1990.

<u>Creel Surveys</u>

Largemouth bass anglers

Creel survey results from 1998-2010 show an annual mean bass angler effort of 5.8 hours per acre of bass habitat (2,100 acres). This amount of effort may not be sufficient to "drive" a protected slot limit given the recreational fishing estimate of 30 hours/acre necessary according to Eder (1984). Even the highest recorded bass angler effort on Vernon Lake in 2005 (9.1 hours/acre) is only one third the amount of effort thought necessary for a length regulation to have an effect on largemouth bass population size structure. Additionally, the 2010 survey estimated that 82.8% of legal sized bass (outside protected slot limit) were released. As per the LMB population assessment, "*if anglers remain hesitant to harvest LMB* *of legal size and fishing mortality remains low, the effectiveness of any size regulation to manage the Vernon Lake LMB population is severely limited."* (Appendix II). This lack of bass harvest was a significant factor in removing the protective slot limit.

Creel survey data indicates most fishing trips are between 3 to 5 hours with 2,000 to 4,000 anglers traveling between 15 to 25 miles to reach the launch annually (Table 2). While angler effort varies from year to year, catch rates have remained steady since 1998 at three to four bass caught per trip (Table 3). Sixty-three to 72% of the annual estimated largemouth bass that were released were less than 14 inches TL. With the exception of 2005, almost no fish were released above the slot limit (Table 4).

Table 2. Annual averages of angler party size, duration of fishing trip, and distance traveled from residence to boat ramp for all years of creel surveys on Vernon Lake, LA, 1989 – 2010.

Bass Anglers				
Year	Total # of anglers	Mean # of anglers in party	Mean length of fishing trip (hrs.)	Mean one-way distance traveled to ramp
1989	3491	1.72	3.06	15
1995	3539	1.87	3.95	24
1998	2661	1.57	4.49	13
2005	4087	1.92	5.19	20
2010*	2066	1.85	2.73	19
* State spending freezes from mid-March through mid-April suspended creel surveys during this time. This lack of interviews may have biased this data				

Table 3. Annual data for largemouth bass caught per trip, released per trip, harvested per trip, and mean weight of harvested bass for all years of creel surveys on Vernon Lake, LA, 1989 - 2010.

Bass Anglers				
Creel Year	# LMB caught per trip	#LMB released per trip	# LMB harvested per trip	Average weight of harvested LMB
1989	1.18	0.60	0.58	1.16
1995	0.86	0.62	0.23	1.90
1998	4.14	2.79	1.35	0.94
2005	3.05	1.39	1.67	0.86
2010*	3.37	2.99	0.38	0.61
* State spending freezes from mid-March through mid-April suspended creel surveys during this time. This lack of interviews may have biased this data				

Table 4. Annual data for total number of largemouth bass harvested, released, and released below, in, and above 14”-17” protected slot for all years of creel surveys on Vernon Lake, LA, 1989 – 2010.

Bass Anglers					
Creel Year	Total #LMB harvested	Total #LMB released	#LMB released below slot	#LMB released in slot	#LMB released above slot
1989	1991.5	1013.9	N/A	N/A	N/A
1995	1074.6	2947.7	2050.0	897.0	0.0
1998	2972.2	4024.5	2902.0	1123.0	0.0
2005	6077.4	7154.9	4500.0	2566.0	89.0
2010*	453.0	3408.0	2221.0	1187.0	0.0
* State spending freezes from mid-March through mid-April suspended creel surveys during this time. This lack of interviews may have biased this data					

Commercial

Little commercial fishing is conducted on Vernon Lake. Catfish species are available for commercial harvest subject to the gear restrictions listed above.

HABITAT EVALUATION

Aquatic Vegetation

Unlike other inland reservoirs in Louisiana, Vernon Lake has few problems with overabundant aquatic vegetation. In fact, the low abundance of submersed aquatic plants has reduced the fisheries productivity of Vernon Reservoir. Annual type mapping surveys from 2005-2008 show *Chara* spp. to be the predominant submersed plant. Unfortunately the fisheries value of *Chara* spp. is low. The predominant emergent plants included (in order of declining dominance) floating primrose, yellow water lily, and rushes (*Juncus* spp.). Low aquatic plant abundance is due to several factors including water quality and poor soil fertility. From 2010 to 2015, water clarity was significantly improved (Figure 16), and aquatic plant abundance has increased. The most beneficial increase observed was in lily pad beds (*Nymphoides aquatica*), coontail (*Ceratophyllum demersum*), and variable leaf pondweed (*Potamogeton diversifolius*). Stonewort (*Nitella* spp.) was also thriving in shallow cove areas and had taken the place of *Chara* spp. as the predominant submersed plant. Stonewort, while not ideal for complex cover, is providing beneficial cover to juvenile fish. The September 2015 aquatic weed type map survey indicated increased coverage of coontail and less coverage of Chara. Turbidity also showed an improvement from the last two years (Figure 16). A map created for the type map in September 2015 can be found in Appendix IV.

In 2013, in conjunction with the Anacoco Lake plant restoration effort, 3,000 eel grass *(Vallisneria americana)* rhizomes were planted in coves on the southern end of the lake (Appendix I). Monitoring of this planting is ongoing through 2016, with the most recent survey (April 2016) observing no *Vallisneria* at planting sites.

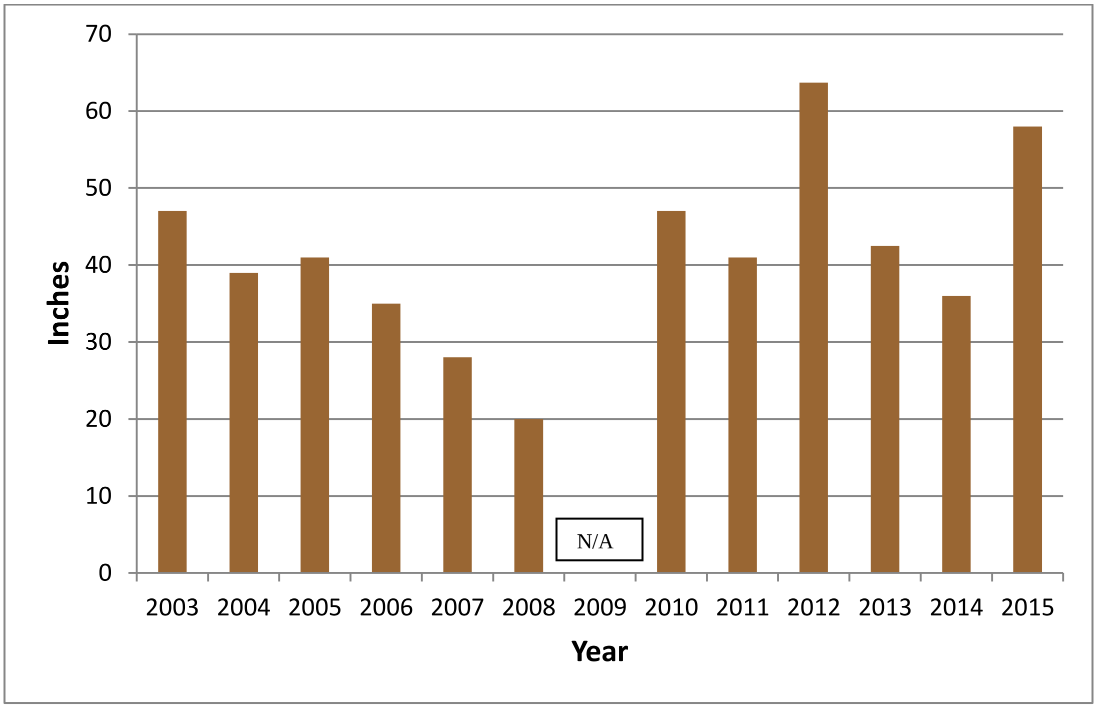

Figure 16. Secchi disk transparency measurements taken during vegetative type mapping for Vernon Lake, LA, from 2003-2015.

Spawning Habitat

Firm bottoms with little organic accumulation provide nest building fish with ample spawning substrate in the lake. The abundance of inundated and fallen riparian timber also provides cavity nesters (catfishes) with sufficient areas for reproduction. Spawning habitat is not a limiting factor in Vernon Lake.

Juvenile habitat

With the increased abundance of native, beneficial aquatic vegetation since 2010, cover for juvenile centrarchids has increased significantly. With approximately 10% of the lake having some type of complex cover, juvenile habitat is a minor limiting factor in Vernon Lake

Adult habitat

While all of the lake may be used by different species at certain times of the year, a thermocline is often present in the lower portion of the lake during the warmer summer months. There are approximately 2,100 acres (50%) of the lake outside of the thermocline which is considered bass habitat. The lake also does not have a significant population of pelagic predators (striped bass/white bass) that would utilize the large portion of available open water habitat. Because almost half the lake is only seasonally used by centrarchids, adult habitat is a limiting factor for these species.

Fertility

Overall fertility has declined since inundation due to the natural aging process of the reservoir. The soils in the Vernon Lake watershed are also relatively nutrient poor, limiting nutrient inputs from the watershed. Overall, water fertility is the primary limiting factor in Vernon Lake.

Problem Vegetation

Unlike many of our inland reservoirs, Vernon has very few aquatic plant problems from either submersed or emergent vegetation. The predominant problematic plants are water primrose (*Ludwigia* spp.) and alligator weed (*Alternanthera philoxeroides*), primarily located in shallow flats on the northern third of the lake. In 2015 crews treated two small areas for giant salvinia. These areas are also often associated with home/camp sites, so while not large in size, the affected areas cause access issues if left untreated. Since treatment of these areas began in 2010 (particularly Paradise Cove), LDWF crews have successfully reduced the overall biomass of nuisance vegetation by approximately 80%.

Estimated Nuisance plant coverage in Vernon Lake as of May 2016
Lotus (100 acres)
Watershield (175 acres)
Common Salvinia (30 acres)
Alligatorweed (40 acres)
Primrose (25 acres)
Banana Lilly (75 acres)

Substrate
Bottom substrates of Vernon Reservoir consist primarily of hard packed river sand interspersed with red clay banks and Asiatic clams, the primary aquatic invasive species found there.

Artificial Structure
The only artificial structures found in Vernon Lake consist of wharves, piers, and duck blinds.

CONDITION IMBALANCE / PROBLEM

While complex cover has increased significantly overall, additional coverage in the coves located in the southern third of the lake may be beneficial.

CORRECTIVE ACTION NEEDED

Continue to establish and promote desirable native aquatic vegetation in proper amounts (15 – 30 % coverage). The sport fisheries of Vernon Lake could be more fully realized with a proper balance of submersed aquatic vegetation. Vegetation provides edge effect (food & cover) for invertebrates and fishes thereby increasing their numbers and abundance.

RECOMMENDATIONS

1) Identify areas that may benefit from additional aquatic vegetation. Increase coverage in these areas through plantings or in-lake transplanting of beneficial aquatic vegetation.

2) Continue to monitor success of previous plantings.

3) Work with Vernon Parish Police Jury to identify and stabilize exposed soil areas that may be sources of non-point runoff turbidity, i.e., BMP for shoreline development, bridge crossings, gravel roads and drive-ways, and clear-cutting forestry practices.

4) Continue to monitor LMB populations and size structures to document any effects of the removal of the slot limit.

5) Continue Florida bass stockings to maintain documented Florida genome introgression.

6) LDWF spray crews will continue treating emergent and floating vegetation on an as-needed basis with either glyphosate (0.75 gal/acre) or diquat (0.75 gal/acre) and an approved surfactant (0.25 gal/acre). A mixture of diquat (0.25 gal/acre) and glyphosate (0.75 gal/acre) with Turbulence (0.25 gal/acre) surfactant may be applied to common salvinia. Alligator weed will be controlled with imazapyr (0.5 gal/acre) in undeveloped areas and with Clearcast (0.5 gal/acre) near houses and developed shorelines. Turbulence surfactant (0.25 gal/acre) will be used in conjunction with both of these herbicides.

7) Evaluate the 2016 drawdown during and afterwards to determine if the 7 year cycle is appropriate.

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APPENDIX I – Restoration Plan For Native Plants in Vernon Lake
(Return to aquatic vegetation)

Restoration Plan for Native Aquatic Plants in Vernon Reservoir

The objective of these plantings will be to establish/restore beneficial, native, aquatic plants in both Anacoco and Vernon Lakes. This will consist of a multi-tiered approach with different plants combining effects and benefits to provide overall enhancement to fisheries habitat within the lakes. Plants will be divided between Anacoco and Vernon Lakes based on need, with the bulk of the plantings occurring on Anacoco Lake as per the 2012 LDWF drawdown plan.

Plant	Quantity	Benefits
Bullwhip (*Scirpus californicus*)	3000	Shoreline protection, fisheries habitat
Fragrant water lily (*Nymphaea odorata*)	7500	Break up wind action, bottom stabilization, fisheries habitat
Eel grass (*Vallisneria americana*)	15000	Complex cover for fish (habitat), bottom stabilization
Total:	28500	

The Vernon Parish Police Jury will provide funds through the Vernon Parish Game and Fish Commission to purchase plants. Labor and installation will be provided jointly by Vernon Parish and LDWF.

<u>Schedule:</u>
Fall 2012: Prior to conclusion of 2012 drawdown, plant bullwhips around margins of the lake (accomplished).

Spring 2013: Purchase water lily and eel grass from Wildlife Nurseries Inc. Disperse pre-weighted plants into designated target areas (accomplished). Exclosures will be constructed on some plots to test for herbivory.

Summer 2013 through winter 2014: Plant establishment will be assessed quarterly.

1.

APPENDIX II
(Return to document)

LOUISIANA DEPARTMENT OF WILDLIFE & FISHERIES

OFFICE OF FISHERIES
INLAND FISHERIES SECTION
FISHERIES MANAGEMENT SECTION

Vernon Lake Largemouth Bass:
Population and Fishery Characteristics
With Size Regulation Simulations

TECHNICAL REPORT SERIES
Baton Rouge, Louisiana
2013

Joe West, Steve Beck, and Dawn Davis
Fisheries Management Section
Louisiana Department of Wildlife of Fisheries

Introduction

With increased public demand for evaluation of Louisiana (LA) largemouth bass (LMB; *Micropterus salmoides*) harvest regulations, assessment of current management strategy is necessary. Before the efficacy of waterbody-specific harvest regulations can be determined, accurate and precise estimates of the present fishery and population are needed. The primary goal of this project was to develop a statewide database of LMB population and fishery characteristics to inform and evaluate future management decisions.

The success of LMB harvest regulation depends on the vital rate functions, i.e. growth, mortality, and recruitment, of the populations in question. The behaviors of anglers utilizing these fisheries (e.g., rate of voluntary catch and release) are also important. If anglers are hesitant to harvest fish of legal size, potential benefits of length limit restrictions (e.g., protected slot limits and increased growth rates) may not by realized (Allen et al. 2002). Minimum length limits are recommended for populations characterized by low rates of recruitment and natural mortality, moderate to fast growth rates, and high fishing mortality; whereas protected slot limits are recommended for populations characterized by high recruitment and low growth rates (Novinger 1984; Noble and Jones 1993). The Vernon Lake LMB fishery is currently managed with a 14 to 17 inch protective slot limit and an eight fish per day harvest limit, with four fish allowed over 17 inches.

This report presents Vernon Lake LMB population and fishery characteristics and compares these results to other LA waterbodies included in this project that completed sampling by 2012. Additionally, an age and sex structured population model was constructed to simulate effects of multiple size regulations on Vernon Lake LMB fishery performance.

Methods

Fishery Independent Collections

Largemouth bass were sampled with standardized LA Department of Wildlife and Fisheries (LDWF) spring electrofishing surveys (LDWF Waterbody Management Plan 1994) for a minimum of three years. If spring electrofishing collections weren't applicable (e.g., riverine systems with a high spring flood pulse), fall electrofishing surveys were substituted. The overall sampling objective was the collection of a minimum of 500 individuals to represent the current size/age distribution of the LMB population in question.

Age Determination

A random sub-sample of up to 10 individuals per inch group <16 inches were sacrificed from each annual electrofishing survey for age determination. Due to larger variation in length-at-age of older LMB, all individuals collected ≥16 inches were sacrificed. Sagittal otoliths were removed, cleaned, and stored in glycerin for processing at the LDWF Office of Fisheries Age and Growth Lab.

Biological ages were assigned to individual fish by assuming an April 1st birthday and adjusting ages to correspond with sample collection dates relative to this birthday (e.g., young-of-the year collected on October 1st would be 0.5 years old). Due to temporal variation in LA LMB annulus formation (i.e., February-June; LDWF unpublished data), biological ages were also adjusted to ensure individual fish were assigned to the correct cohort. For example, biological ages of spring collected LMB without evidence of annuli formation on the otolith margin were advanced by one year; spring collected LMB with evidence of annuli formation on the otolith margin were not adjusted. Biological ages were then used to estimate both sex and non-sex-specific von Bertalanffy growth parameters (see *Growth* section for details).

Annual length at age sample matrices were then converted to age-length-keys, where each matrix cell of annual length at age samples was normalized by the sum of its row to generate empirical probabilities of age given length. These age-length-keys were then used to assign ages to the non-sacrificed LMB collected from each annual electrofishing survey.

Population Characteristics

Growth: The von Bertalanffy (1938) growth function (VBGF) was used to model length at age. The function is configured as:

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right) \quad [1]$$

where L_t is mean total length (TL) at age in years, L_∞ is the asymptotic average maximum TL, K is the rate at which length approaches L_∞, and t_0 is the theoretical age when TL=0. The model was fit to the three year dataset using the SAS nonlinear approximation procedure (PROC NLIN; SAS 1996). Statistical outliers (i.e, absolute studentized residuals >2.5) were then removed and the model refit. The average times to reach stock, quality, and preferred sizes were then estimated by inverting equation [1] and solving for time.

Size Structure Indices: Proportional size distribution indices (PSD-X) were calculated over the 3 year sampling period following methods given in Neumann et al. (2012) as:

$$PSD - X = \frac{Number\ of\ fish \geq length\ of\ interest}{Number\ of\ fish \geq minimum\ stock\ length} \times 100 \quad [2]$$

where X indicates the length category of interest (i.e., quality [Q] or preferred [P] sizes; 12 and 15 inches respectively).

Length/Weight Relationship: Weight-length regressions were estimated following methods given in Neumann et al. (2012). The relationship between weight and length can be described with the power function:

$$W = aL^b \quad [3]$$

where W is weight, L is total length, a is the weight-length constant and b is the allometric exponent. The model, after common logarithmic transformation, was fit to the three year dataset with the SAS linear regression procedure (PROC REG; SAS 1996). Statistical outliers (i.e., absolute studentized residuals > 2.5) were then removed and the model refit.

Condition: Condition indices provide a measure of the relative ‘plumpness’ of fish (Neumann et al. 2012). Mean relative weights of stock, quality, and preferred size fish (i.e., 8, 12, and 15 inches respectively) over the three year sampling period were calculated following methods given in Neumann et al. (2012). Relative weights (W_r) for individual fish were calculated from:

$$W_r = (W/W_s) \times 100 \quad [4]$$

where W is the weight of an individual fish and W_s is a length-specific standard weight reported by Henson (1991).

Recruitment: Mean annual catch rates of age-1 LMB collected from electrofishing surveys were used to calculate a coefficient of variation (CV; standard deviation/mean×100) representing the inter-annual variability in recruitment over the three year electrofishing sampling period.

Mortality: Total instantaneous mortality (Z) was estimated with catch curve analysis (Ricker 1975). The model describing the exponential reduction in abundance at age is configured as:

$$N_{t+1} = N_t e^{-Z_t} \quad [5]$$

where N_t is the number of individuals alive at time t, N_{t+1} is the number alive the following time interval, and Z_t is the instantaneous total mortality rate at time t. Equation [5] is linearized by taking the natural logarithm of both sides to obtain:

$$log_e(N_{t+1}) = log_e(N_t) - Z(t) \quad [6]$$

which was solved with the SAS linear regression procedure (PROC REG; SAS 1996). The interval (i.e., annual in this case) total mortality rate A is then calculated from:

$$A = 1 - e^{-Z} \quad [7]$$

Assumptions of catch curve analysis are: 1) mortality is constant across ages, 2) recruitment is constant, and 3) samples are representative of the true age structure of the population. To alleviate the possibility of violating assumption (1), only the ages considered exploitable, (i.e., not protected by length regulations as determined by predicted mean TL at age computed from equation [1]) were included in the catch curve. To reduce the possibility of violating assumption (2) and concerns with inadequacies in sample size, samples over the three year sampling period were used to create a single pseudo-cohort. Because sampling occurred in successive years with unequal sampling efforts, age-specific mean catch per unit effort over the three year sampling period was substituted for the age-specific number of individuals (N_t) in Equation [6]. Additionally, only age classes considered fully-recruited to the electrofishing gear and containing more than three individuals from the three year sampling period were included in the catch curve.

Instantaneous natural mortality (M) was approximated following the approach recommended by Hewitt and Hoenig (2005) as:

$$M \sim \frac{4.22}{t_{max}} \quad [8]$$

where t_{max} represents the maximum age in the population. For this project, t_{max} is taken as the oldest age observed in the population or 8 years, whichever is greater. Instantaneous fishing mortality (F) was then approximated by difference, i.e. $Z - M$.

Most LA LMB fisheries can be categorized as Type 2 fisheries, where natural and fishing mortality occur simultaneously. Interval natural (v) and fishing (u) mortality rates for Type 2 fisheries are calculated from:

$$v = \frac{MA}{Z} \;\; , \;\; u = \frac{FA}{Z} \quad [9, 10]$$

where Z, F, and M are instantaneous total, fishing, and natural mortality rates respectively, and A is the interval total mortality rate.

Fishery Characteristics

A LDWF Inland Fisheries creel survey (LDWF Waterbody Management Plan 1994) was conducted once during the three year fishery-independent sampling period for each waterbody included in this project. Estimates of the proportion of legal sized LMB retained (i.e., harvested), calculated as the ratio of the annual harvest to annual catch of legal sized LMB, are presented in this report. Fishery-specific estimates are used in LMB length limit simulations for each waterbody included in this project (see *Population Simulations* Section below).

Population Simulations

An age and sex structured population model was constructed to simulate the effects of size-specific harvest regulations (i.e., no length limit, a 14 inch minimum length limit, a 14 to 17 inch protected slot limit, and a17 inch maximum length limit) on Vernon Lake LMB fishery performance.

Model Configuration: Abundance at age a and sex s was modeled as:

$$N_{a,s} = R_s S_{a,s} \quad [11]$$

where R_s is equilibrium sex-specific constant recruitment calculated from $R \times 0.5$. Sex-specific survivorship-at-age ($S_{a,s}$) was calculated recursively from $S_{a,s-1}e^{-Z_{a,s}}$, $S_{1,s} = 1$ where $Z_{a,s}$ are age and sex-specific total instantaneous mortality rates. Separated into additive components this becomes:

$$Z_{a,s} = M + H_{a,s} + D_{a,s} \quad [12]$$

where M is the constant non-sex-specific instantaneous natural mortality rate taken from equation [8]. Instantaneous sex-specific harvest and discard mortalities ($H_{a,s}$, $D_{a,s}$) vary across ages. Age and sex-specific instantaneous harvest mortalities were calculated from:

$$H_{a,s} = FV_{h(a,s)} \quad [13]$$

where F is the overall instantaneous fishing mortality rate and $V_{h(a,s)}$ are the age and sex-specific vulnerabilities to harvest. Age and sex-specific instantaneous discard mortalities were calculated from:

$$D_{a,s} = FdV_{d(a,s)} \quad [14]$$

where d is the proportion of discards not surviving and $V_{d(a,s)}$ are the age and sex-specific vulnerabilities to discarding.

Age and sex-specific vulnerabilities to harvest and discard were developed as knife-edged vectors evaluated with predicted mean total lengths at age calculated from equation [1] using the sex-specific Vernon Lake von Bertalanffy growth parameters for each simulated size-specific harvest regulation. Vulnerabilities to harvest were calculated as the product of the retention rate of legal sized LMB estimated from the Vernon Lake creel survey (see *Fishery Characteristics* Section for details) and the proportion of legal sized LMB of age a and sex s, evaluated with equation [1], for each simulated size regulation. Vulnerabilities to discard were calculated similarly, but as two components: 1) the proportion of non-legal size LMB of age a and sex s larger than the minimum size vulnerable to the fishery, and 2) the proportion of legal sized fish of age a and sex s reduced by the retention rate estimate of legal sized fish. To approximate changes in growth through each age interval, TL at age was calculated using the age interval midpoints (i.e. $a + 0.5$).

Fishery Performance: Equilibrium total catch (i.e., harvest + releases) and total catches ≥ 15 or 20 inches were used to evaluate Vernon Lake LMB fishery performance.

Equilibrium harvest (i.e., number of individuals harvested) was calculated as:

$$C_H = \sum_a \sum_s N_{a,s} H_{a,s} \frac{(1-e^{-Z_{a,s}})}{Z_{a,s,}} \quad [17]$$

Equilibrium releases (i.e., number of individuals discarded) was calculated as:

$$C_R = \sum_a \sum_s \frac{N_{a,s} D_{a,s} \frac{(1-e^{-Z_{a,s}})}{Z_{a,s,}}}{d} \quad [18]$$

Equilibrium total catch (C_T; harvest + discards) was then calculated by summation ($C_H + C_R$). Equilibrium total catches of individuals greater than preferred and memorable sizes were calculated with equations [17-19], but where summation only occurs over ages with TL ≥ 15 or 20 inches respectively.

Results (return to LMBsize)

Fishery-independent Collections:

Annual size frequency distributions of LMB collected from spring Vernon Lake electrofishing surveys are presented in Figure 1 below.

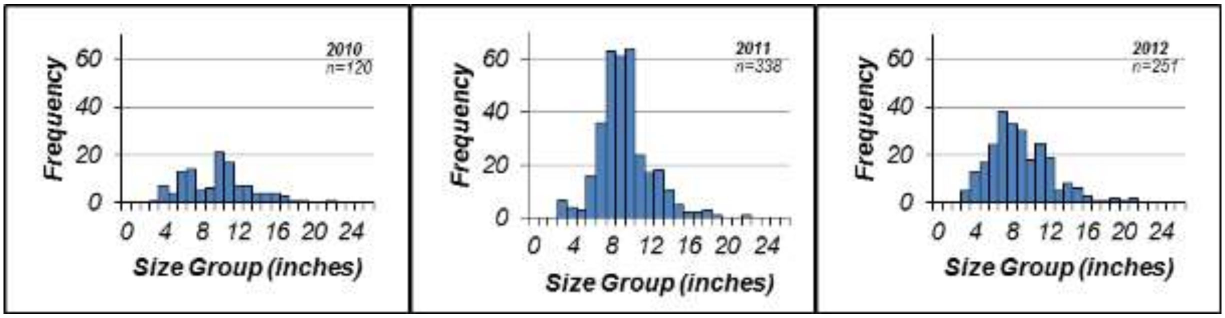

Figure 1: Annual size frequency distributions of the Vernon Lake largemouth bass spring electrofishing survey 2010-2012. Sample sizes (n) are presented in each graphic.

Age Determination (return to age & growth)

Annual length at age sample matrices of LMB from spring Vernon Lake electrofishing surveys 2010-2012 are presented in Table 1 below.

Table 1: Annual length at age sample matrices of the Vernon Lake spring electrofishing survey 2010-2012. Totals represent the sum across rows/columns.

2010

TL / Age	0	1	2	3	4	5	6	7	8	9	10	Totals
2												
3		1										1
4		7										7
5		4										4
6		10										10
7		10										10
8		4	1									5
9			5	1								6
10			8	1								9
11			7	4								11
12			2	4	1							7
13			1	4	2							7
14				1	1	2						4
15				1		2	1					4
16					2	2						4
17							2			1		3
18						1						1
19								1				1
20												
21												
22								1				1
23									1		1	2
24												
25												
Totals		36	24	16	6	7	3	2	1	1	1	97

2011

TL / Age	0	1	2	3	4	5	6	7	8	9	10	Totals
2												
3		6										6
4		3										3
5		3										3
6		9										9
7		10										10
8		10										10
9		9	1									10
10		12										12
11			9									9
12			9	1								10
13			8	2	1							11
14				7	2							9
15				1	4							5
16				1	1							2
17					1	1						2
18							3					3
19						1						1
20												
21												
22									1			1
23												
24												
25												
Totals		62	27	12	9	2	3		1			116

2012

TL / Age	0	1	2	3	4	5	6	7	8	9	10	Totals
2												
3		5										5
4		10										10
5		10										10
6		10										10
7		10										10
8		11										11
9		9										9
10		4	6									10
11			10									10
12			10									10
13			3	1	1							5
14			8									8
15			2	3	1							6
16				1	1	1						3
17					1							1
18						1						1
19							1	1				2
20								1				1
21									1	1		2
22												
23												
24												
25												
Totals		69	39	5	4	2	1	2	1	1		124

Population Characteristics

Growth: Observed and predicted TL at age of LMB collected from Vernon Lake fishery independent surveys (2010-2012) are presented in Figure 2 below.

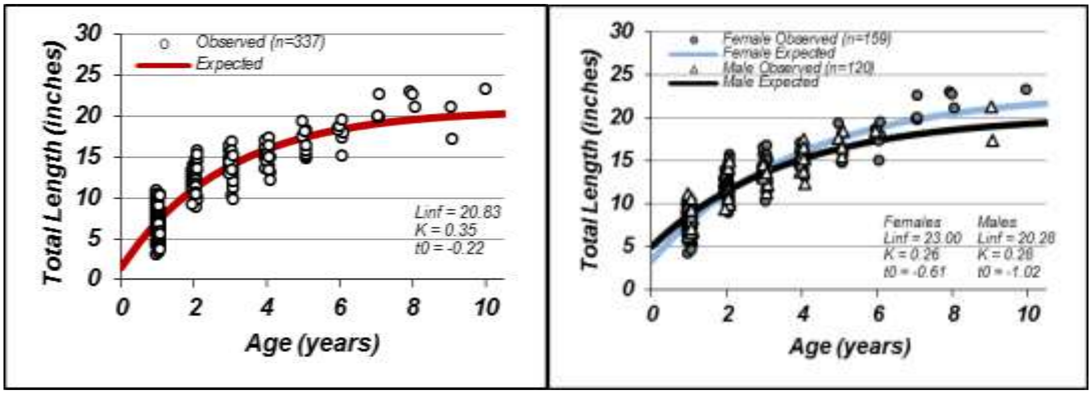

Figure 2: Observed and predicted total length at age of Vernon Lake largemouth bass (2010-2012). Von Bertalanffy parameter estimates and sample sizes (n) are presented in each graphic. Right graphic depicts sex-specific von Bertalanffy model fits and parameter estimates.

Average time in years for LMB (i.e., non-sex-specific) to reach stock, quality, and preferred sizes for waterbodies included in this project are presented in Table 2 below. This table illustrates variation in LMB growth rates among waterbodies.

Table 2: Average time in years for LMB to reach stock, quality, and preferred sizes (Growth_type). Average times are sorted from lowest to highest with Vernon Lake results highlighted. (return to size indices)

Waterbody	Growth_type	Years	Season	Time_yrs
Poverty	t_stock	2010-12	Spring	0.73
Concordia	t_stock	2010-12	Spring	0.91
False	t_stock	2010-12	Spring	0.94
D'Arbonne	t_stock	2010-12	Spring	1.04
Toledo	t_stock	2010-12	Spring	1.14
Black/Clear	t_stock	2010-12	Spring	1.15
Vernon	t_stock	2010-12	Spring	1.16
Cross	t_stock	2010-12	Spring	1.22
Atchafalaya	t_stock	2009-11	Fall	1.28
Chicot	t_stock	2010-12	Spring	1.29
Cataouatche	t_stock	2010-12	Spring	1.30

Waterbody	Growth_type	Years	Season	Time_yrs
Poverty	t_quality	2010-12	Spring	1.56
Concordia	t_quality	2010-12	Spring	1.89
False	t_quality	2010-12	Spring	2.00
D'Arbonne	t_quality	2010-12	Spring	2.12
Chicot	t_quality	2010-12	Spring	2.12
Toledo	t_quality	2010-12	Spring	2.19
Vernon	t_quality	2010-12	Spring	2.20
Black/Clear	t_quality	2010-12	Spring	2.26
Cross	t_quality	2010-12	Spring	2.27
Cataouatche	t_quality	2010-12	Spring	2.39
Atchafalaya	t_quality	2009-11	Fall	2.46

Waterbody	Growth_type	Years	Season	Time_yrs
Poverty	t_preferred	2010-12	Spring	2.57
Concordia	t_preferred	2010-12	Spring	3.08
Chicot	t_preferred	2010-12	Spring	3.27
Toledo	t_preferred	2010-12	Spring	3.35
False	t_preferred	2010-12	Spring	3.36
D'Arbonne	t_preferred	2010-12	Spring	3.39
Vernon	t_preferred	2010-12	Spring	3.44
Cross	t_preferred	2010-12	Spring	3.48
Black/Clear	t_preferred	2010-12	Spring	3.58
Cataouatche	t_preferred	2010-12	Spring	3.77
Atchafalaya	t_preferred	2009-11	Fall	3.90

Size Structure Indices: Mean proportional size distribution indices (PSD-Q and PSD-P) of LMB collected over the three year electrofishing sampling period for waterbodies included in this project are presented in Table 3 below. This table illustrates variation in PSD indices among LA LMB populations.

Table 3: LMB proportional size distribution indices (PSD-Q and PSD-P), upper and lower 95% confidence intervals (CI), and years and season of electrofishing collections. Size structure indices are sorted from highest to lowest with Vernon Lake results highlighted. (Return to relative abundance)

Waterbody	Years	Season	PSD-Q	L95%CI	U95%CI
Poverty	2010-12	Spring	82.3	79.5	85.1
False	2010-12	Spring	74.4	72.0	76.9
Cross	2010-12	Spring	71.2	68.5	73.8
Chicot	2010-12	Spring	67.7	63.8	71.6
Concordia	2010-12	Spring	67.3	64.2	70.3
D'Arbonne	2010-12	Spring	60.7	56.8	64.6
Toledo	2010-12	Spring	51.2	49.4	53.1
Black/Clear	2010-12	Spring	40.8	37.5	44.0
Atchafalaya	2009-11	Fall	37.7	33.8	41.6
Cataouatche	2010-12	Spring	36.7	33.1	40.3
Vernon	2010-12	Spring	30.3	26.3	34.2

Waterbody	Years	Season	PSD-P	L95%CI	U95%CI
Poverty	2010-12	Spring	59.6	56.0	63.2
Cross	2010-12	Spring	39.2	36.4	42.1
Chicot	2010-12	Spring	38.7	34.6	42.8
Concordia	2010-12	Spring	32.5	29.5	35.5
D'Arbonne	2010-12	Spring	22.3	19.0	25.6
False	2010-12	Spring	15.4	13.4	17.5
Black/Clear	2010-12	Spring	12.7	10.5	15.0
Toledo	2010-12	Spring	11.9	10.7	13.1
Cataouatche	2010-12	Spring	9.2	7.0	11.3
Vernon	2010-12	Spring	8.7	6.2	11.1
Atchafalaya	2009-11	Fall	5.2	3.4	7.0

Length/Weight Relationship: Observed and predicted LMB weight at total length developed from Vernon Lake fishery independent surveys (2010-2012) are presented in Figure 3 below.

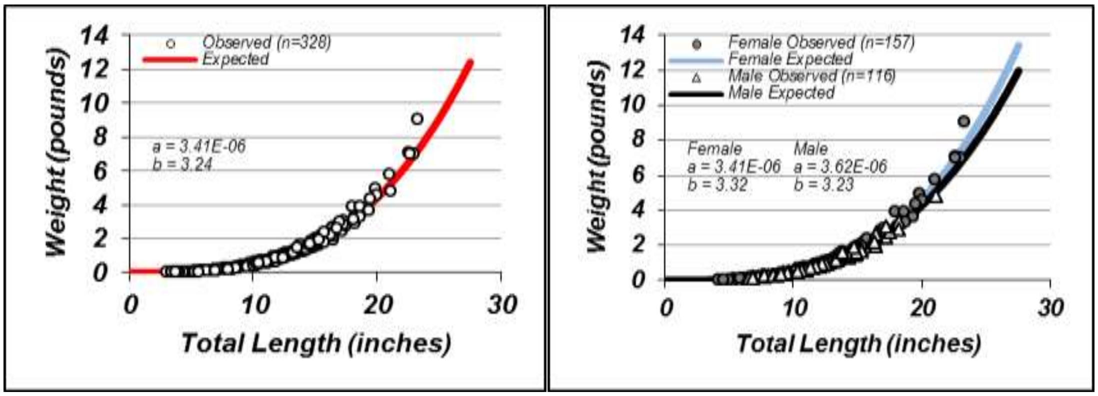

Figure 3: Observed and predicted weight at total length of Vernon Lake largemouth bass 2010-2012. Parameter estimates for the power function $W = aTL^b$ and sample sizes (n) used in model fitting are presented in each graphic. Right graphic depicts sex-specific weight-length relationships and parameter estimates.

Condition: Mean relative weights of stock, quality and preferred sized LMB collected from electrofishing surveys for waterbodies included in this project are presented in Table 4 below. This table illustrates variation in condition indices among LA LMB populations.

Table 4: Mean relative weights (W_r) of stock, quality and preferred size LMB (listed under Size) as three-year averages. Upper and lower 95% confidence intervals (CI), and years and season of electrofishing collections are also presented. Mean relative weights are sorted from highest to lowest with Vernon Lake results highlighted. (Return to relative wt)

Waterbody	Size	Years	Season	Wr	L95%CI	U95%CI
Cross	Stock	2010-12	Spring	107.9	106.7	109.1
Concordia	Stock	2010-12	Spring	107.6	103.1	112.1
Atchafalaya	Stock	2009-11	Fall	106.6	105.8	107.5
Black/Clear	Stock	2010-12	Spring	105.7	103.9	107.5
Toledo	Stock	2010-12	Spring	103.4	102.5	104.3
False	Stock	2010-12	Spring	100.0	99.0	101.0
Poverty	Stock	2010-12	Spring	99.7	97.1	102.4
D'Arbonne	Stock	2010-12	Spring	99.7	97.3	102.1
Cataouatche	Stock	2010-12	Spring	99.4	98.1	100.6
Chicot	Stock	2010-12	Spring	98.7	97.1	100.3
Vernon	Stock	2010-12	Spring	97.7	96.4	99.0

Waterbody	Size	Years	Season	Wr	L95%CI	U95%CI
Poverty	Quality	2010-12	Spring	111.2	109.4	113.0
Atchafalaya	Quality	2009-11	Fall	107.4	106.0	108.9
Cross	Quality	2010-11	Spring	105.6	104.4	106.8
Concordia	Quality	2010-12	Spring	102.7	101.3	104.0
Chicot	Quality	2010-12	Spring	101.9	100.1	103.7
Black/Clear	Quality	2010-12	Spring	99.1	97.8	100.5
Toledo	Quality	2010-12	Spring	99.0	98.4	99.6
D'Arbonne	Quality	2010-12	Spring	97.6	96.2	99.1
Cataouatche	Quality	2010-12	Spring	95.8	94.5	97.2
Vernon	Quality	2010-12	Spring	95.1	93.5	96.7
False	Quality	2010-12	Spring	92.1	91.4	92.8

Waterbody	Size	Years	Season	Wr	L95%CI	U95%CI
Poverty	Preferred	2010-12	Spring	114.7	113.5	116.0
Atchafalaya	Preferred	2009-11	Fall	109.3	104.3	114.3
Cross	Preferred	2010-11	Spring	105.7	104.7	106.7
Concordia	Preferred	2010-12	Spring	103.9	102.4	105.3
Cataouatche	Preferred	2010-12	Spring	99.5	96.5	102.6
Chicot	Preferred	2010-12	Spring	98.4	96.6	100.3
Black/Clear	Preferred	2010-12	Spring	98.0	96.3	99.7
Toledo	Preferred	2010-12	Spring	97.3	96.2	98.4
Vernon	Preferred	2010-12	Spring	96.7	93.3	100.1
D'Arbonne	Preferred	2010-12	Spring	94.0	91.6	96.3
False	Preferred	2010-12	Spring	91.9	90.5	93.2

Recruitment: Coefficients of variation describing the magnitude of variation in annual mean age-1 spring electrofishing catch rates for waterbodies included in this project are presented in Table 5 below. This table illustrates variation in inter-annual recruitment among LA LMB populations

Table 5: Coefficients of variation describing the magnitude of variation in mean annual age-1 electrofishing catch rates. Also presented are years and season of LMB electrofishing collections. Coefficients of variation are sorted from lowest to highest with Vernon Lake results highlighted.

Waterbody	Years	Season	CV
D'Arbonne	2010-12	Spring	10
Cross	2010-12	Spring	24
Toledo	2010-12	Spring	28
Cataouatche	2010-12	Spring	42
Poverty	2010-12	Spring	49
False	2010-12	Spring	52
Concordia	2010-12	Spring	59
Vernon	2010-12	Spring	70
Chicot	2010-12	Spring	73
Black/Clear	2010-12	Spring	96
Atchafalaya	2009-11	Fall	116

Mortality: Total catch at age, mean CPUE at age, and corresponding 95% confidence intervals for the spring Vernon Lake electrofishing survey (2010-2012) are presented in Table 6 below. The shaded area identifies ages included in the catch curve analysis. Age-1 catches were considered not fully-recruited to LDWF electrofishing gear and excluded from model fitting.

Table 6: Total catch, mean predicted total length at age, and mean catch per unit effort (CPUE) at age for the Vernon Lake largemouth bass spring electrofishing survey (2010-2012). Shaded area represents ages included in the catch curve analysis.

Age	Catch	TL (inches)	CPUE	L95%CI	U95%CI
0	0				
1	458	7.2	31.1	24.8	37.5
2	165	11.2	10.6	8.8	12.5
3	40	14.0	2.7	2.0	3.5
4	20	16.0	1.4	1.0	1.8
5	11	17.4	0.8	0.4	1.3
6	7	18.4	0.4	0.1	0.7
7	4	19.1	0.3	0.0	0.6
8	2	19.6	0.1	0.0	0.2
9	2	20.0	0.1	0.0	0.2

Observed and predicted mean log_eCPUE at age of LMB collected from Vernon Lake spring electrofishing surveys (2010-2012) are presented in Figure 4 below.

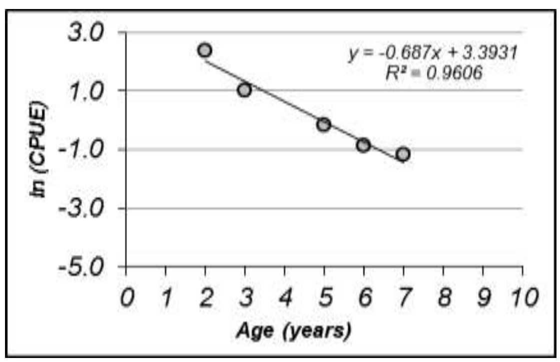

Figure 4: Observed (circles) and predicted (line) mean log_e catch per unit effort of the Vernon Lake largemouth bass spring electrofishing survey (2010-2012). The catch curve equation and coefficient of determination (R^2) are presented in graphic.

Instantaneous and interval total, natural, and fishing mortality rate estimates for the Vernon Lake LMB population (2010-2012) are presented in Table 7 below.

Table 7: Vernon Lake LMB mortality estimates, upper and lower 95% confidence intervals (CI), and derivation descriptions.

Mortality Type		Estimate	U95%CI	L95%CI	Derivation
Z (total)	Instantaneous	-0.69	-0.43	-0.94	Catch curve (ages 2,3,5-7)
M (natural)	Instantaneous	-0.42	.	.	4.22 / t_{max}
F (fishing)	Instantaneous	-0.26	.	.	Z-M
AM (total)	Interval	0.50	0.61	0.35	1-exp^Z
v (natural)	Interval	0.31	.	.	M*AM/Z
u (fishing)	Interval	0.19	.	.	F*AM/Z

Total instantaneous and interval mortality rate estimates for LMB populations included in this project are presented in Table 8 below. This table illustrates variation in total mortality rate estimates among LA LMB populations.

Table 8: Total instantaneous (Z) and interval (A) mortality rates for waterbodies included in this project, ages included in each catch curve, 95% confidence intervals, years of electrofishing collections, and current size limit regulations. Estimates are sorted from lowest to highest with Vernon Lake results highlighted. Note: Total mortality for the Atchafalaya LMB population was not estimable following the methodology detailed in this report.

Waterbody	Years	Ages	Size Regulation	Z	L95%CI	U95%CI	A	L95%CI	U95%CI
Chicot	2010-12	2,5-9	14-17" PSL	-0.42	-0.71	-0.12	0.34	0.12	0.51
Poverty	2010-12	2,6-11	15-19" PSL	-0.42	-0.59	-0.26	0.34	0.23	0.44
Cross	2010-12	2,3,5-9	14-17" PSL	-0.66	-0.92	-0.40	0.48	0.33	0.60
Vernon	2010-12	2,3,5-7	14-17" PSL	-0.69	-0.94	-0.43	0.50	0.35	0.61
Concordia	2010-12	2-8	None	-0.69	-0.97	-0.42	0.50	0.34	0.62
Black/Clear	2010-12	2-8	None	-0.83	-1.07	-0.58	0.56	0.44	0.66
D'Arbonne	2010-12	2-7	None	-0.83	-0.94	-0.72	0.57	0.52	0.61
False	2010-12	3-8	14" MinLL	-0.86	-1.21	-0.51	0.58	0.40	0.70
Cataouatche	2010-12	2-7	None	-0.90	-1.00	-0.80	0.59	0.55	0.63
Toledo	2010-12	3-8	14" MinLL	-1.04	-1.14	-0.94	0.65	0.61	0.68

Maximum observed age for LMB populations included in this project are presented in Table 9 below. This table illustrates variation in longevity among LA LMB populations.

Table 9: Maximum observed age of LMB for waterbodies included in this project,and years of electrofishing collections. Maximum observed ages are sorted from highest to lowest with Vernon Lake results highlighted.

Waterbody	Age_max	Years
Cross	12	2010-12
Poverty	11	2010-12
Toledo	11	2010-12
D'Arbonne	10	2010-12
Vernon	10	2010-12
Chicot	10	2010-12
False	9	2010-12
Atchafalaya	9	2009-11
Black/Clear	8	2010-12
Concordia	8	2010-12
Cataouatche	7	2010-12

Instantaneous and interval fishing mortality rate estimates (F and u respectively) for LMB populations included in this project are presented in Table 10 below. This table illustrates variation in fishing mortality rate estimates among LA LMB populations.

Table 10: Instantaneous and interval fishing mortality rate estimates ($F$and u) for waterbodies included in this project, ages included in each catch curve, years of electrofishing collections, and current size limit regulations. Estimates are sorted from highest to lowest with Vernon Lake results highlighted. Note: Fishing mortality for the Atchafalaya LMB population was not estimable following the methodology detailed in this report.

Waterbody	Size Regulation	Years	Ages	F	u
Toledo	14" MinLL	2010-12	3-8	-0.66	0.41
D'Arbonne	None	2010-12	2-7	-0.41	0.28
False	14" MinLL	2010-12	3-8	-0.39	0.26
Cataouatche	None	2010-12	2-7	-0.37	0.25
Cross	14-17" PSL	2010-12	2,3,5-9	-0.31	0.23
Black/Clear	None	2010-12	2-8	-0.30	0.20
Vernon	14-17" PSL	2010-12	2,3,5-7	-0.26	0.19
Concordia	None	2010-12	2-8	-0.17	0.12
Poverty	15-19" PSL	2010-12	2,6-11	-0.04	0.03
Chicot	14-17" PSL	2010-12	2,5-9	-0.03	0.03

Fishery Characteristics

A LDWF creel survey was conducted on Vernon Lake from January through December 2010. Estimates of the percent retention of legal sized LMB for waterbodies included in this project are provided in Table 11 below. Estimates represent LMB anglers only.

Table 11: Percent retention of legal sized LMB and creel survey year(s) for waterbodies included in this project. Results are sorted from highest to lowest with Vernon Lake results highlighted.

Waterbody	Metric	Estimate	Year(s)
Toledo	%LMB_retained (legal sizes only)	61.2	2009,10
Concordia	%LMB_retained (legal sizes only)	46.4	2010
Black/Clear	%LMB_retained (legal sizes only)	46.3	2010
Cataouatche	%LMB_retained (legal sizes only)	24.8	2010,11
Chicot	%LMB_retained (legal sizes only)	22.8	2010,11
D'Arbonne	%LMB_retained (legal sizes only)	17.5	2011
Vernon	%LMB_retained (legal sizes only)	17.2	2010
False	%LMB_retained (legal sizes only)	12.8	2010
Atchafalaya	%LMB_retained (legal sizes only)	10.6	2009
Cross	%LMB_retained (legal sizes only)	8.0	2010
Poverty	%LMB_retained (legal sizes only)	7.8	2012

Population Simulations

Parameter values used in the Vernon Lake LMB age and sex structured simulation model are presented in Table 12 below.

Table 12: Parameter values used in the Vernon Lake age and sex structured LMB population simulations.

Parameter	Description	Values
Age_max	Longevity (years)	10
M	Instantaneous natural mortality rate (years^{-1})	0.42
F	Instantaneous fishing mortality rate (years^{-1})	0 to 2.0
%retention	Retention rate of legal sized LMB	17%
d	Discard mortality rate (proportion not surviving)	0.1
R	Constant recruitment	10000
Lvul	Length at recruitment to fishery (inches)	8.0
Linf_female	Female asymptotic average maximum length (inches)	23.00
K_female	Female von Bertalanffy growth coefficient	0.26
t0_female	Female von Bertalanffy time at zero TL (years)	-0.61
a_female	Female length-weight constant	2.21E-06
b_female	Female length-weight allometric parameter	3.32
Linf_male	Male asymptotic average maximum length (inches)	20.28
K_male	Male von Bertalanffy growth coefficient	0.28
t0_male	Male von Bertalanffy time at zero TL (years)	-1.02
a_male	Male length-weight constant	3.62E-06
b_male	Male length-weight allometric parameter	3.23

Simulation results illustrating the effect of four size regulations: 1) no length limit, 2) a 14 inch minimum length limit, 3) a 17 inch maximum length limit, and 4) a 14 to 17 inch protected slot limit on the Vernon Lake LMB fishery are presented in Figures 5 and 6 below.

Figure 5 illustrates the effect of each simulated size regulation on Vernon Lake LMB total catch (i.e., harvest + releases), total catch of individuals ≥ 15 inches (preferred size), and total catch of individuals ≥ 20 inches (memorable size) as a function of instantaneous fishing mortality.

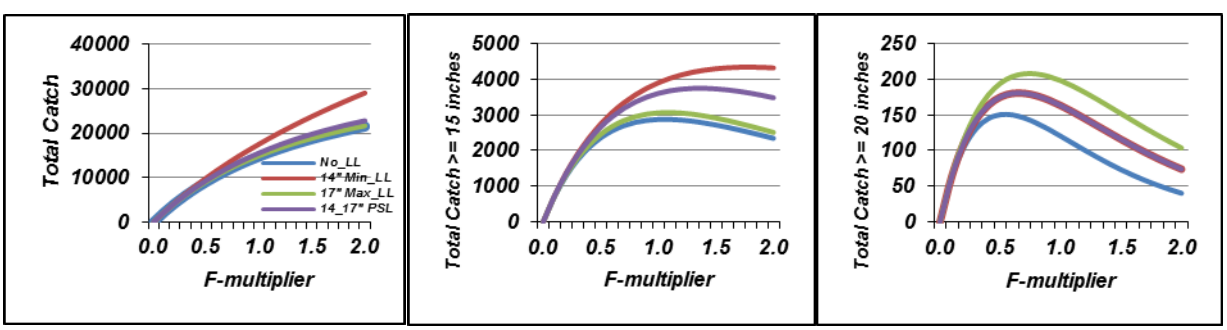

Figure 5: Model results illustrating the effect of four simulated size regulations (i.e., no length limit, a 14 inch minimum length limit, a 17 inch maximum length limit, and a 14-17 inch protected slot limit) on Vernon Lake LMB total catch, and total catch ≥15 and 20 inches versus instantaneous fishing mortality (F-multiplier). A 17% retention rate estimate of legal sized LMB derived from the Vernon Lake creel survey was applied in this simulation. Note: Units are relative to constant recruitment of 10,000 individuals.

Figure 6 illustrates the effect of each simulated size regulation on Vernon Lake LMB total catch ≥ 15 inches as a function of instantaneous fishing mortality at three different retention rates of legal sized LMB, i.e. high (100%), moderate (50%), and low (5%). These results demonstrate the efficacy of size regulations across a range of retention rates of legal sized LMB.

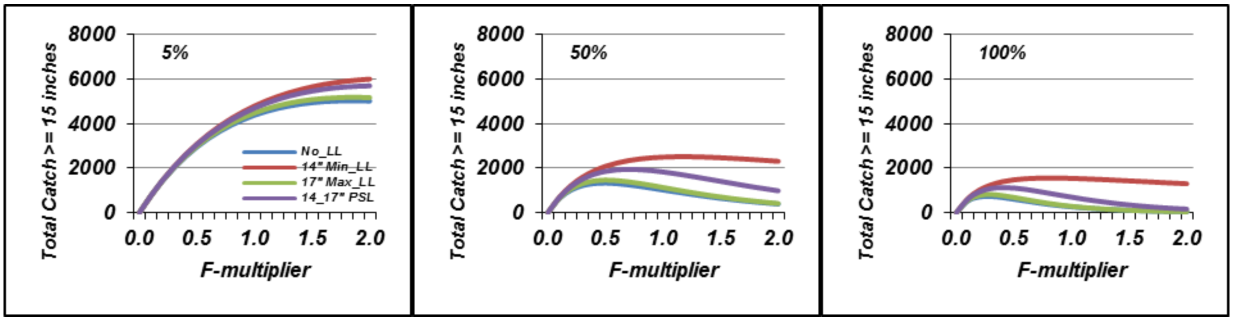

Figure 6: Model results illustrating the effect of four simulated size regulations (i.e., no length limit, a 14 inch minimum length limit, a 17 inch maximum length limit, and a 14-17 inch protected slot limit) on Vernon Lake LMB total catch ≥ 15 inches versus instantaneous fishing mortality (F-multiplier). Each graphic represents a different retention rate of legal sized LMB (from left to right; 5, 50 and 100% respectively). Note: Units are relative to constant recruitment of 10,000 individuals.

Figure 7 illustrates the effects of a 14 inch minimum length limit on LMB total catch (left graphic), total catch of LMB ≥ 15 inches (center graphic), and total catch of LMB ≥ 20 inches (right graphic) as functions of instantaneous fishing mortality for three LA LMB population types: 1) fast growth and low natural mortality rates (Poverty Point Reservoir), 2) moderate growth and natural mortality rates (Vernon Lake), and slow growth and high natural mortality rates (Lake Cataouatche). Each population type was parameterized with each population's sex-specific von Bertalanffy and weight-length relationship parameter estimates. Each population was simulated with the same TL at recruitment to the fishery (8 inches) and the average fishery retention rate of legal sized LMB for all waterbodies included in this study (25%). These results demonstrate size regulation effectiveness for various LA LMB population types.

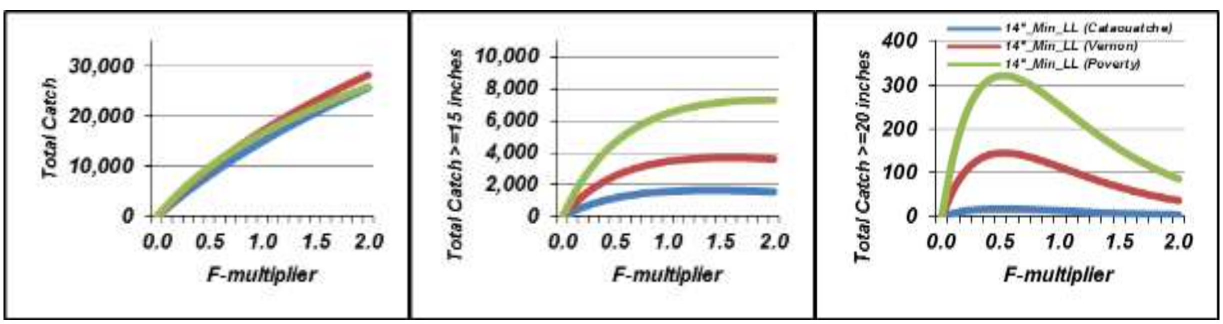

Figure 7: Model results for three LA LMB population types: 1) fast growth and low natural mortality rate (Poverty Point Reservoir), 2) moderate growth and natural mortality rates (Vernon Lake), and 3) slow growth and high natural mortality rates (Lake Cataouatche) illustrating the effects of a 14 inch minimum length limit on LMB total catch (left graphic), total catch of LMB ≥ 15 inches (center graphic), and total catch of LMB ≥ 20 inches (right graphic) versus instantaneous fishing mortality (F-multiplier). Each population was simulated with a 25% retention rate of legal sized LMB.

Discussion:

Population Characteristics:

Growth: An examination of Table 2 shows the Vernon Lake LMB population has a moderate growth rate when compared to other waterbodies included in this project. The time in years to reach stock, quality and preferred sizes for the Vernon Lake LMB population (1.2, 2.2, and 3.4 years, respectively) are higher than the population exhibiting the fastest growth rate (Poverty Point Reservoir; 0.7, 1.6, and 2.6 years respectively), but lower than the population exhibiting the slowest growth rate (Atchafalaya Basin: 1.3, 2.5, and 3.9 years respectively). The Black/Clear Lake and Cross Lake LMB population growth rates are most similar to the Vernon Lake LMB population.

The method of von Bertalanffy model fitting used in this assessment assumed that the data are representative samples of lengths from each age-class. If this assumption fails (e.g., size-selective sampling and cumulative effects of fishing mortality), model parameters can only describe the current population available to harvest (Taylor et al. 2005). In other words, the current VBGF fitting methodology may underestimate growth when faster growing individuals are removed from the population disproportionaly due to size-selective fishing mortality. If determining potential growth rates under a no harvest scenario is of interest, then the methodology detailed in Taylor et al. (2005) could be used in future analyses.

Size Structure Indices: An examination of Table 3 indicates the Vernon Lake LMB population has a smaller proportion of individuals that are larger than quality size than all other waterbodies included in this project. The Vernon Lake proportional size distribution (PSD) index for quality and larger sized fish (PSD-Q; 30) is substantiality less than the highest estimate (Poverty Point Reservoir; 82). The Vernon Lake PSD index for preferred and larger sized fish (PSD-P; 9) is also substantiality less than the highest estimate (Poverty Point Reservoir; 60) and is the second lowest PSD-P estimate for this project. When compared to the Vernon Lake LMB population, the Atchafalaya Basin and Lake Cataouatche populations have the most similar PSD indices.

Optimum ranges of PSD indices have been proposed for maintaining balanced LMB populations (Neumann et al. 2012). Vernon Lake estimates for quality and preferred sized LMB (PSD-Q = 30 and PSD-P = 9) fall below the recommended ranges (PSD: 40-70 and PSD-P: 10-40). Indices falling outside these ranges may indicate unstable LMB recruitment, growth, and mortality, or that population density is above optimum levels.

An important assumption in obtaining unbiased estimates of PSD indices is that samples are representative of the standing LMB population size structure. If this assumption fails (e.g., dome-shaped vulnerability to survey gear where older fish are not fully represented in samples), estimates will be biased low. This is an important limitation not only for unbiased estimates of population size structure, but also for obtaining accurate estimates of age-specific relative abundance and subsequent estimates of total mortality.

Condition: Table 4 presents size-specific mean relative weight estimates for waterbodies included in this project. The Vernon Lake mean W_r estimates of stock, quality and preferred sized fish (98, 95, and 97 respectively) are within the recommended range (95-105) of a balanced LMB population (Neumann et al. 2012). However, mean relative weights of Vernon Lake LMB are among the lowest when compared with other project waterbodies. Mean W_r estimates well below 100 may indicate a problem with prey availability or feeding conditions (Neumann et al. 2012).

Recruitment: Vernon Lake LMB recruitment can be considered highly variable (CV=70; Table 5). Of the waterbodies included in this project, only three waterbodies exhibited more variability in annual age-1 CPUE (Chicot Lake, Black/Clear Lake, and the Atchafalaya Basin; CV=73, 96, and 116 respectively). The Bayou D'Arbonne Lake LMB population exhibited the lowest variability in recruitment (CV=10).

Via simulation analysis, Allen and Pine (2000) demonstrate that LMB population responses to length limit implementation are often obscured by variable recruitment. Their results suggest that populations with above average recruitment variability may not have detectable responses to length limit implementation, unless the regulation change is significant. Vernon Lake inter-annual recruitment variability was higher than most populations included in this study; however, each coefficient of variation was estimated with only three years of data. Future analyses incorporating annual age-1 CPUE data over a longer time-series will allow a more accurate assessment of recruitment variability in and among LA LMB populations.

Mortality: The Vernon Lake LMB population has the fourth lowest estimate of total mortality (Z=-0.69/year; A=0.50/year) when compared to the other populations included in this project (Table 8). The lowest total mortality rate (Z=-0.42/year; A=0.34/year) is estimated for the Chicot Lake LMB population; the highest estimate (Z=-1.04/year; A=0.65/year) is for the Toledo Bend Reservoir LMB population. Of the waterbodies included in this project, LMB populations with fisheries currently managed with protected slot limits have the lowest total mortality estimates.

To obtain unbiased estimates of total mortality rates via catch curve analysis, three assumptions must be met: 1) mortality is constant across ages, 2) recruitment is constant, and 3) samples are representative of the true age structure in the population. The first two assumptions are rarely met, but their impacts are lessened in this assessment as described in *Methods*. If the third assumption of representative sampling is not met (e.g., dome-shaped vulnerability to survey gear), mortality rate estimates will be biased. Future efforts utilizing mark and recapture techniques could be initiated to elucidate size-specific LMB vulnerability to LDWF electrofishing gear.

The Vernon Lake LMB population has a maximum observed age of 10 years (Table 9). The Cross Lake population has the highest age observed (12 years); the Lake Cataouatche population has the lowest (7 years). Given the approximation of M from equation [8], LMB populations with low maximum observed ages correspond to higher estimates of M; populations with high maximum observed ages correspond to lower estimates of M. However, if exploitation is high in the population in question, and all ages are considered exploitable, equation [8] is unlikely to provide a reliable estimate of M.

The Vernon Lake LMB population has a moderate fishing mortality rate (F=-0.26/year; u=0.19/year) when compared to other LMB populations included in this project (Table 10). The lowest fishing mortality rate estimate is for the Chicot Lake LMB population (F=-0.03/year; u=0.03/year); the highest estimate (F=-0.66/year; u=0.41/year) is for the Toledo Bend Reservoir LMB population. Fishing mortality rate estimates presented in this report are approximated by difference (i.e., $Z - M$). If approximation of M from equation [8] is unreliable due to high exploitation, fishing mortality estimates would also be considered uncertain. Future efforts to directly estimate M could reduce this uncertainty.

<u>Fishery Characteristics</u>

The annual estimate of the percent of legal sized LMB retained from the Vernon Lake fishery was 17% (Table 11). The highest estimates were for the Toledo Bend Reservoir (61%), Lake Concordia (46%), and Black/Clear Lake (46%). The lowest estimates were for Cross Lake and Poverty Point Reservoir (both 8%). The percent of legal sized LMB retained, averaged across fisheries included in this project, was 25% (i.e., a 75% voluntary catch and release rate).

<u>Population Simulations:</u>

Population simulations presented in this report are based on equilibrium conditions (i.e., long-term averages) and do not include more complex dynamics such as recruitment variability, density dependent growth, and environmental conditions.

Simulation results presented in Figure 5 indicate that length limit restrictions would have negligible effects on Vernon Lake LMB catches (i.e., total catch and total catches $\geq$ 15 and 20 inches) at low levels of fishing mortality. At moderate to high levels of fishing mortality, total catch and total catch of LMB $\geq$ 15 inches could be maximized with a 14 inch minimum length limit, whereas total catch of LMB $\geq$ 20 inches could be maximized with a 17 inch maximum length limit. The estimate of F for the Vernon Lake LMB population is 0.26/year.

In recent decades, a voluntary catch-and-release ethic has become popular among LMB anglers (Quinn 1996). The estimated percent of legal sized LMB retained for the Vernon Lake fishery (17%) indicates a moderate to high level of voluntary catch and release (83%). Simulation results presented in Figure 6 demonstrate the consequence of increasing voluntary catch and release rates on LMB catches ≥ 15 inches. As voluntary catch and release increases, simulated catches increase substantially due to higher abundance in the population (i.e., less fish are removed). However, the effectiveness of length limit regulations is substantially reduced as voluntary catch and release rates increases, where much higher levels of F (i.e., effort) are needed to detect differences in fishery response (i.e., catches) for each simulated size regulation. A discard mortality rate of 10% is applied in all simulations. If discard mortality is higher in fisheries with greater levels of voluntary catch and release then the potential benefits of this practice (i.e., higher catches) would be reduced.

Simulation results presented in Figure 7 clearly show that LMB populations with fast growth and low natural mortality rates support fisheries with considerably higher total catches of LMB ≥ 15 and 20 inches when compared to fisheries of populations with slower growth and higher natural mortality rates (center and right graphics). These results support earlier work of Beamesderfer and North (1995) and Allen et al. (2002), who found that LMB populations characterized by slow growth and high natural mortality rates have the least potential for desirable population responses from length limit implementation.

Conclusions (return to size indices)

It is important to note that LMB populations and their fisheries are not only influenced by fishing effort, but also by anthropogenic and environmental factors. The type and degree of human activity within watersheds, riparian zones, and specific waterbodies can affect LMB populations by altering critical habitats. Additional factors influencing LMB populations include aquatic vegetation coverage, water level management, supplemental LMB stocking programs, and habitat improvements. The frequency of floods, drought, and hurricanes can also influence LMB populations. While consideration of these factors are important in effective fisheries management, evaluating how these factors affect the Vernon Lake LMB population/fishery is beyond the scope of this report.

The Vernon Lake LMB population has a moderate maximum age, growth rate, and mortality rate, with high recruitment variability when compared with the other LMB populations included in this project. The prevalence of voluntary catch and release in the Vernon Lake fishery is relatively high when compared to other fisheries included in this project. The Vernon Lake LMB fishery is currently managed with a 14 to 17 inch protected slot limit and an eight fish per day harvest limit with no more than four fish allowed over 17 inches. Given the dynamics of the Vernon Lake LMB population and fishery, the existing size regulation has minor influence on fishery catches. Furthermore, if anglers remain hesitant to harvest LMB of legal size and fishing mortality remains low, the effectiveness of any size regulation to manage the Vernon Lake LMB population is severely limited. (Return to LMB anglers)

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APPENDIX III
(return to document)

LOUISIANA DEPARTMENT OF WILDLIFE & FISHERIES

OFFICE OF FISHERIES
INLAND FISHERIES SECTION
FISHERIES MANAGEMENT SECTION

Vernon Lake Crappie: Population and Fishery Characteristics

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2014

Vernon Lake Crappie:
Population and Fishery Characteristics with Size Regulation Simulations
2014 Report

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Introduction:
Given the popularity of crappie (sac au lait, white perch, *Pomoxis* spp.) angling in Louisiana (LA), it is necessary to regularly assess management strategies. Before the efficacy of waterbody-specific harvest regulations can be determined, accurate and precise estimates of the present fishery and population are needed. The primary goal of this project was to develop a statewide database of crappie population and fishery characteristics to inform and evaluate future management decisions.
The success of crappie harvest regulation depends on the vital rate functions, i.e. growth, mortality, and recruitment, of the populations in question. The goal of most Louisiana crappie anglers is to maximize harvest (i.e., yield) as opposed to catching trophy size fish, therefore the goal of crappie management in Louisiana is often to maximize yield. Crappie population models indicate that minimum length limits have the potential to increase yield if a population demonstrates fast growth and low natural mortality (Allen and Miranda 1995). In practice, implementing a minimum length limit can result in improved yields (Webb and Ott 1991) or reduced yields if conditions are not appropriate (Boxrucker 2002). The Vernon Lake crappie fishery is managed with a 50 fish creel limit with no length limit.
This report presents characteristics of the Vernon Lake crappie population and fishery and compares these characteristics to other LA waterbodies included in this project. Additionally, an equilibrium age and sex structured population model was constructed to simulate effects of multiple size regulations on the Vernon Lake crappie fishery. White crappie (*Pomoxis annularis*) and black crappie (*Pomoxis nigromaculatus*) are not independently managed; therefore most population and fishery characteristics presented in this report are not separated by species.

Methods:
Fishery Independent Collections:

Crappie were sampled with standardized LA Department of Wildlife and Fisheries (LDWF) fall lead net surveys from 2009 to 2011. The overall sampling objective was the collection of a minimum of 500 individuals to represent the current size/age distribution of the crappie population in question.
Age Determination:
A random sub-sample of up to 10 individuals per species per inch group <12 inches were sacrificed from each annual lead net survey for age determination. Due to larger variation in length-at-age of older crappie, all individuals collected ≥12 inches were sacrificed. Sagittal otoliths were removed, cleaned, and stored in glycerin for processing at the LDWF Office of Fisheries Age and Growth Lab.
Biological ages were assigned to individual fish by assuming a March 1st hatch date and adjusting ages to correspond with sample collection dates relative to this hatch date (e.g., young-of-the-year collected on September 1st would be 0.5 years old). Due to temporal variation in LA crappie annulus formation, biological ages were also adjusted to ensure individual fish were assigned to the correct cohort. For example, biological ages of fall collected crappie with evidence of annuli formation on the otolith margin were reduced by one year; fall collected crappie without evidence of annuli formation on the otolith margin were not adjusted. Biological ages were then used to estimate both sex and non-sex-specific von Bertalanffy growth parameters (see *Growth* section for details).
Annual length at age sample matrices were then converted to age-length-keys, where each matrix cell of annual length at age samples was normalized by the sum of its row to generate empirical probabilities of age given length. These age-length-keys were then used to assign ages to the non-sacrificed crappie collected from each annual lead net survey.
Population Characteristics:
Growth: The von Bertalanffy (1938) growth function (VBGF) was used to model length at age of the combined crappie population. The function is configured as:

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right) \quad [1]$$

where L_t is mean total length (TL) at age in years, L_∞ is the asymptotic average maximum TL, K is the rate at which length approaches L_∞, and t_0 is the theoretical age when TL=0. The model was fit to the four year dataset using the SAS nonlinear approximation procedure (PROC NLIN; SAS 1996). Statistical outliers (i.e, absolute studentized residuals >2.5) were then removed and the model refit. Due to size selectivity of the lead net sampling gear resulting in only the fastest growing young-of-the-year fish represented in the samples, and to prevent unrelasitic parameter estimates, the t_0 parameter was fixed at 0. The average times to reach stock, quality, and preferred sizes were then estimated by inverting equation [1] and solving for time.

Size Structure Indices: Proportional size distribution indices (PSD-X) were calculated over the sampling period following methods given in Neumann et al. (2012) as:

$$PSD - X = \frac{Number\ of\ fish \geq length\ of\ interest}{Number\ of\ fish \geq minimum\ stock\ length} \times 100 \quad [2]$$

where X indicates the length category of interest (i.e., quality [Q], preferred [P], or memorable [M] sizes; 8, 10, and 12 inches total length, respectively).

Length/Weight Relationship: Weight-length regressions were estimated for the combined crappie population following methods given in Neumann et al. (2012). The relationship between weight and length can be described with the power function:

$$W = aL^b \quad [3]$$

where $W$is weight, L is total length, a is the weight-length constant and b is the allometric exponent. The model, after common logarithmic transformation, was fit to the three year dataset with the SAS linear regression procedure (PROC REG; SAS 1996). Statistical outliers (i.e., absolute studentized residuals > 2.5) were then removed and the model refit.

Condition: Condition indices provide a measure of the relative 'plumpness' of fish (Neumann et al. 2012). Mean relative weights of quality, preferred, memorable, and trophy size fish (i.e., 8, 10, 12, and 15 inches respectively) over the four year sampling period were calculated separately for black and white crappie following methods given in Neumann et al. (2012). Relative weights (W_r) for individual fish were calculated from:

$$W_r = (W/W_s) \times 100 \quad [4]$$

where W is the weight of an individual fish and W_s is a length-specific standard weight reported by Neumann and Murphy (1991).

Recruitment: Mean annual catch rates of age-1 crappie collected from lead net surveys were used to calculate a coefficient of variation (CV; standard deviation/mean×100) representing the inter-annual variability in recruitment over the four year sampling period. Waterbody-specific mean annual age-1 catch rates were also compared to the mean annual age-1 catch rates for all waterbodies included in the study.

Mortality: Total instantaneous mortality (Z) was estimated with catch curve analysis (Ricker 1975). The model describing the exponential reduction in abundance at age is configured as:

$$N_{t+1} = N_t e^{-Z_t} \quad [5]$$

where N_t is the number of individuals alive at time t, N_{t+1} is the number alive the following time interval, and Z_t is the instantaneous total mortality rate at time t. Equation [5] is linearized by taking the natural logarithm of both sides to obtain:

$$log_e(N_{t+1}) = log_e(N_t) - Z(t) \quad [6]$$

which was solved with the SAS linear regression procedure (PROC REG; SAS 1996). The interval (i.e., annual in this case) total mortality rate A is then calculated from:

$$A = 1 - e^{-Z} \quad [7]$$

Assumptions of catch curve analysis are: 1) mortality is constant across ages, 2) recruitment is constant, and 3) samples are representative of the true age structure of the population. To reduce the possibility of violating assumption (2) and concerns with inadequacies in sample size, samples over the four year sampling period were used to create a single pseudo-cohort. Because sampling occurred in successive years with unequal sampling efforts, age-specific mean catch per unit effort over the four year sampling period was substituted for the age-specific number of individuals (N_t) in Equation [6]. Additionally, only age classes considered fully-recruited to the lead net gear and containing more than three individuals from the sampling period were included in the catch curve. Instantaneous natural mortality (M) was approximated following the approach recommended by Hewitt and Hoenig (2005) as:

$$M = \frac{4.22}{t_{max}} \quad [8]$$

where t_{max} represents the maximum age in the population. This estimation assumes that the stock is unexploited and approximently1.5% of the stock survives to t_{max}. Because populations in this study are exploited, the maximum observed age of crappie from each waterbodies leadnet samples are unlikely to represent the true maximum age of the unexploited population. Therefore, the maximum observed age was increased by one, two, and three years to approximate high, medium, and low natural mortality scenarios. Instantaneous fishing mortalities (F) corresponding to the low, medium, and high natural mortality scenarios were then approximated by difference, i.e. $Z - M$.

LA crappie fisheries can be categorized as Type 2 fisheries, where natural and fishing mortality occur simultaneously. Interval natural (v) and fishing (u) mortality rates for Type 2 fisheries are calculated from:

$$v = \frac{MA}{Z}\ ,\ u = \frac{FA}{Z} \quad [9, 10]$$

where Z, F, and M are instantaneous total, fishing, and natural mortality rates respectively, and A is the interval total mortality rate.

Fishery Characteristics:

A LDWF Inland Fisheries creel survey (LDWF Waterbody Management Plan 1994) was conducted once during the fishery-independent sampling period for most waterbodies included in this project. Mean crappie harvest per trip by month and frequencies of crappie harvest per angler trip were calculated. Fishery-specific estimates are used in crappie length limit simulations for each waterbody included in this project (see *Population Simulations* Section below).

<u>Population Simulations:</u>

An equilibrium age and sex structured population model was constructed to compare the effects of implementing size-specific harvest regulations (i.e., 10 and 12 inch minimum length limits) on Vernon Lake crappie fishery performance compared to the present regulation (no length limit).

Model Configuration: Abundance at age a and sex s was modeled as:

$$N_{a,s} = R_s S_{a,s} \quad [11]$$

where R_s is equilibrium sex-specific constant recruitment calculated from $R \times 0.5$. Sex-specific survivorship-at-age ($S_{a,s}$) was calculated recursively from $S_{a,s-1}e^{-Z_{a,s}}$, $S_{1,s} = 1$ where $Z_{a,s}$ are age and sex-specific total instantaneous mortality rates. Separated into additive components this becomes:

$$Z_{a,s} = M + H_{a,s} + D_{a,s} \quad [12]$$

where M is the constant non-sex-specific instantaneous natural mortality rate. Three natural mortality scenarios were used to model each size regulation (see *Methods: Population Characteristics: Mortality* section). Instantaneous sex-specific harvest and discard mortalities ($H_{a,s}$, $D_{a,s}$) vary across ages. Age and sex-specific instantaneous harvest mortalities were calculated from:

$$H_{a,s} = FV_{h(a,s)} \quad [13]$$

where F is the overall instantaneous fishing mortality rate and $V_{h(a,s)}$ are the age and sex-specific vulnerabilities to harvest. Age and sex-specific instantaneous discard mortalities were calculated from:

$$D_{a,s} = FdV_{d(a,s)} \quad [14]$$

where d is the proportion of discards not surviving and $V_{d(a,s)}$ are the age and sex-specific vulnerabilities to discarding.

Age and sex-specific vulnerabilities to harvest and discard were developed as knife-edged vectors evaluated with predicted mean total lengths at age calculated from equation [1] using the sex-specific Vernon Lake von Bertalanffy growth parameters. Crappie were considered vulnerable to harvest at a total length of 7 inches, which was the mean minimum size harvested across all lakes included this study (see *Fishery Characteristics* Section for details). Harvest vulnerabilities include the proportion of crappie of age a and sex s, evaluated with equation [1], for each simulated size regulation. Vulnerabilities to discard were calculated similarly, where the proportion of crappie of age a and sex s larger than the minimum size vulnerable to the fishery, but smaller than the minimum length limit, were vulnerable to discard. To approximate changes in growth through each age interval, TL at age was calculated using the age interval midpoints (i.e. $a + 0.5$).

Fishery Performance: Total catch (i.e., harvest + releases), percent of total catch released (i.e., releases/total catch), mean catch and harvest rates per trip, mean weight of harvested crappie and equilibrium yield (pounds harvested) were used to evaluate Vernon Lake crappie fishery performance for each simulation.

Equilibrium harvest (i.e., number of individuals harvested) was calculated as:

$$C_H = \sum_a \sum_s N_{a,s} H_{a,s} \frac{(1-e^{-Z_{a,s}})}{Z_{a,s,}} \quad [15]$$

Equilibrium releases (i.e., number of individuals discarded) was calculated as:

$$C_R = \sum_a \sum_s \frac{N_{a,s} D_{a,s} \frac{(1-e^{-Z_{a,s}})}{Z_{a,s,}}}{d} \quad [16]$$

Equilibrium total catch (C_T; harvest + releases) was then calculated from $C_H + C_R$. Percent of total catch released was then calculated from C_R / C_T.

To predict the effect of size regulations on catch rates per angler trip, we assumed that the mean catch rate from the creel survey (CR_1) corresponds to the “no length limit” simulation equilibrium total catch (C_{T1}). Mean catch rates for minimum length limit simulations (CR_2) were predicted by applying the same relationship to each minimum length limit simulation equilibrium total catch (C_{T2}) and solving for CR_2, where:

$$\frac{CR_1}{C_{T1}} = \frac{CR_2}{C_{T2}} \quad [17]$$

Equation [17] was also used to predict mean harvest rates for minimum length limit simulations, using the relationship between the mean harvest rate from the creel survey (HR_1, substituted for CR_1) and “no length limit” simulation equilibrium harvest (C_{H1}, substituted for C_{T1}).

Mean weight of harvested crappie ($\bar{W}$), was calculated as:

$$\bar{W} = \left(\sum_a \sum_s W_{a,s} H_{a,s}\right) / \sum_a \sum_s H_{a,s} \quad [18]$$

where $W_{a,s}$is the sex-specific mean weight at age as derived from equations [1] and [3].

Equilibrium yield (i.e., pounds harvested) was calculated as:

$$Y = \sum_a \sum_s W_{a,s} H_{a,s} \quad [19]$$

Results:

Fishery-independent Collections:

Annual size frequency distributions of crappie collected from fall Vernon Lake lead net surveys are presented in Figure 1 below.

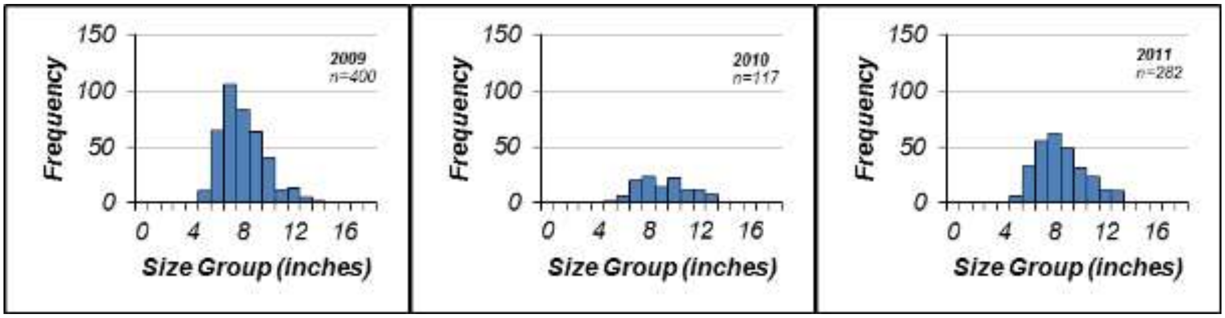

Figure 1: Annual size frequency distributions of Vernon Lake crappie fall lead net surveys (2009-2011). Sample sizes (n) are presented in each graphic.

A summary of total crappie catch by species and year from fall Vernon Lake lead net surveys is presented in Table 1 below.

Table 1: The contribution of black crappie and white crappie to total crappie catch by year for Vernon Lake fall lead net surveys (2009-2011).

Year	*Black Crappie*	*White Crappie*	*Total*
2009	*6 (2%)*	*394 (98%)*	*400*
2010	*25 (21%)*	*92 (79%)*	*117*
2011	*112 (40%)*	*170 (60%)*	*282*
Total	*143 (18%)*	*656 (82%)*	*799*

Age Determination:

Annual length at age sample matrices of crappie from fall Vernon Lake lead net surveys are presented in Table 2 below.

Table 2: Annual length at age sample matrices of Vernon Lake fall lead net surveys (2009-2011). Totals represent the sum across rows/columns.

2009

TL / Age	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Totals*
2												
3												
4												
5		*8*	*3*									*11*
6		*1*	*2*									*3*

7		2	9									11
8			10									10
9		1	8	1								10
10			9	1	1							11
11			2	2	7							11
12			1	3	7	1	1					13
13					1	3	1					5
14									1			1
15												
16												
17												
18												
Totals	0	12	44	7	16	4	2		1			86

2010

TL / Age	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Totals*
2												
3												
4												
5		1										1
6		2	4	1								7
7		4	4	9								17
8		2	7	5								14
9		1	2	9								12
10			4	5								9
11				11		1						12
12				8	2	2						12
13					1	5	1					7
14												
15												
16												
17												
18												
Totals		10	21	48	3	8	1					91

2011

TL / Age	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Totals*
2												
3												
4												
5		6										6
6		14	2									16
7		5	12									17
8		4	9	3	2							18
9		1	10	4	3							18
10			6	5	3							14
11			1	7	3	1						12
12				1	11							12
13				2	7	2						11
14												
15												
16												
17												
18												
Totals		30	40	22	29	3						124

<u>Population Characteristics:</u>
Growth: Observed and predicted TL at age of crappie from Vernon Lake fishery independent surveys (2009-2011) are presented in Figure 2 below.

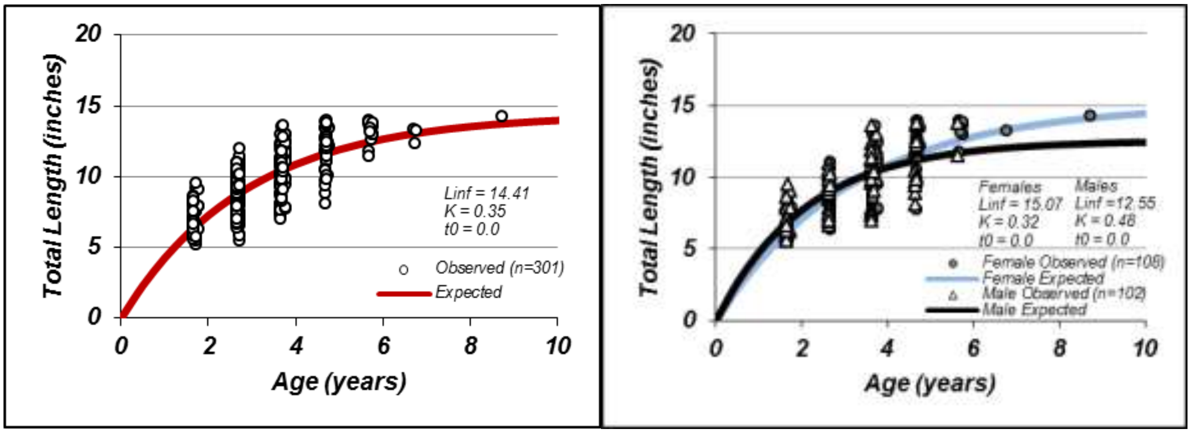

Figure 2: Observed and predicted total length at age of Vernon Lake crappie (2009-2011). Von Bertalanffy parameter estimates and sample sizes (n) are presented in each graphic. Right graphic depicts sex-specific von Bertalanffy model fits and parameter estimates.

Average time in years for crappie (i.e., non-sex-specific) to reach quality (8 inch total length – TL), preferred (10 inch TL), and memorable (12 inch TL) sizes for waterbodies included in this project are presented in Table 3 below. This table illustrates variation in crappie growth rates among waterbodies.

Table 3: Average time in years for crappie to reach quality, preferred, and memorable sizes (Growth_type). Average times are sorted from lowest to highest with Vernon Lake results highlighted.

Waterbody	Growth_type	Years	Time_yrs
Poverty	t_quality	2010-12	0.82
Caddo	t_quality	2011-13	1.23
Toledo Bend	t_quality	2009-11	1.44
Cross	t_quality	2010-12	1.45
D'Arbonne	t_quality	2009-12	1.84
Raccourci	t_quality	2010-13	1.97
Larto/Saline	t_quality	2009-12	2.02
Vernon	t_quality	2009-11	2.25

Waterbody	Growth_type	Years	Time_yrs
Poverty	t_preferred	2010-12	1.26
Caddo	t_preferred	2011-13	1.77
Cross	t_preferred	2010-12	2.09
Toledo Bend	t_preferred	2009-11	2.18
D'Arbonne	t_preferred	2009-12	2.62
Raccourci	t_preferred	2010-13	2.89
Larto/Saline	t_preferred	2009-12	2.95
Vernon	t_preferred	2009-11	3.27

Waterbody	Growth_type	Years	Time_yrs
Poverty	t_memorable	2010-12	2.19
Caddo	t_memorable	2011-13	2.58
Cross	t_memorable	2010-12	3.06
Toledo Bend	t_memorable	2009-11	3.61
D'Arbonne	t_memorable	2009-12	3.73
Raccourci	t_memorable	2010-13	4.41
Larto/Saline	t_memorable	2009-12	4.46
Vernon	t_memorable	2009-11	4.87

Size Structure Indices: Mean proportional size distribution indices (PSD-Q, PSD-P, and PSD-M) of crappie collected over the lead net sampling period for waterbodies included in this project are presented in Table 4 below. This table illustrates variation in PSD indices among LA crappie populations.

Table 4: LA crappie proportional size distribution indices (PSD-Q, PSD-P, and PSD-M), upper and lower 95% confidence intervals (CI), and years of lead net collections. Size structure indices are sorted from highest to lowest with Vernon Lake results highlighted.

Waterbody	Years	PSD-Q	L95%CI	U95%CI
Poverty	2010-12	82.4	80.0	84.7
Toledo Bend	2009-11	75.3	74.1	76.6
Raccourci	2010-13	67.9	65.9	69.8
Vernon	2009-11	64.8	61.5	68.1
Caddo	2011-13	64.6	62.1	67.1
D'Arbonne	2009-12	53.2	50.4	55.9
Cross	2010-12	53.1	50.8	55.4
Larto/Saline	2009-12	38.4	36.0	40.7

Waterbody	Years	PSD-P	L95%CI	U95%CI
Poverty	2010-12	54.6	51.5	57.7
Caddo	2011-13	46.7	44.0	49.3
Raccourci	2010-13	30.0	28.0	31.9
Toledo Bend	2009-11	28.7	27.4	30.0
Vernon	2009-11	26.8	23.7	29.9
Cross	2010-12	24.0	22.0	25.9
D'Arbonne	2009-12	22.9	20.6	25.2
Larto/Saline	2009-12	14.3	12.5	16.0

Waterbody	Years	PSD-M	L95%CI	U95%CI
Caddo	2011-13	22.0	19.8	24.2
Poverty	2010-12	13.8	11.7	16.0
Raccourci	2010-13	8.9	7.7	10.1
Vernon	2009-11	8.8	6.8	10.7
Cross	2010-12	5.4	4.3	6.4
D'Arbonne	2009-12	5.4	4.1	6.6
Larto/Saline	2009-12	3.9	3.0	4.9
Toledo Bend	2009-11	3.6	3.0	4.1

Length/Weight Relationship: Observed and predicted weight at total length developed from Vernon Lake fishery independent surveys are presented in Figure 3.

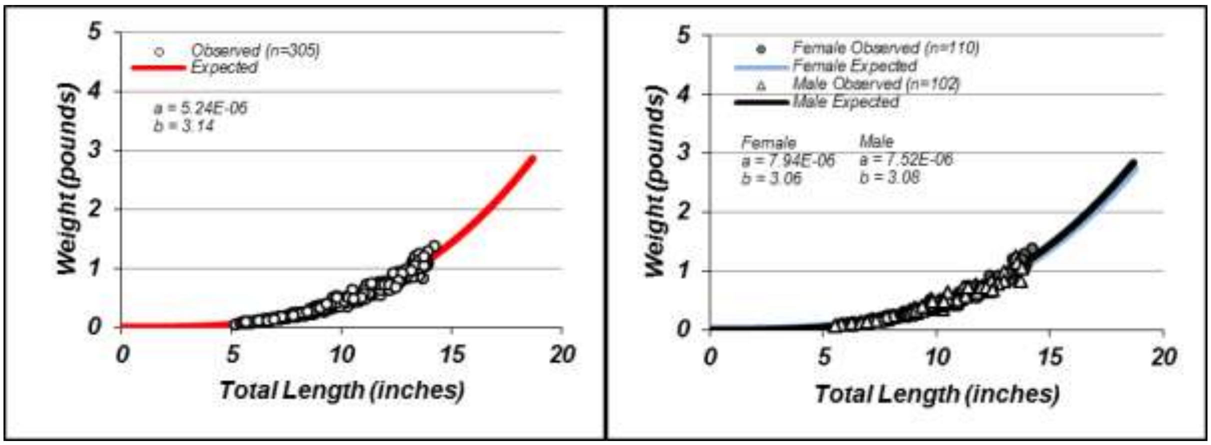

Figure 3: Observed and predicted weight at total length of Vernon Lake crappie (2009-2011). Parameter estimates for the power function $W = aTL^b$ and sample sizes (n) used in model fitting are presented in each graphic. Right graphic depicts sex-specific weight-length relationships and parameter estimates.

Condition: Mean relative weights of quality, preferred, memorable, and trophy (15 inch TL) size black crappie and white crappie collected from lead net surveys for waterbodies included in this project are presented in Tables 5 and 6. This table illustrates variation in condition indices among LA crappie populations.

Table 5: Mean relative weights (W_r) of quality, preferred, memorable, and trophy size **black crappie**. Upper and lower 95% confidence intervals (CI), and years of lead net collections are also presented. Mean relative weights are sorted from highest to lowest with Vernon Lake results highlighted. *NA* indicates that insufficient numbers of fish were collected to generate an estimate.

Quality Size

Waterbody	Years	Wr	L95%CI	U95%CI
Caddo	2011-13	102.7	101.6	103.9
Toledo	2009-11	100.5	100.1	101.0
Cross	2010-12	96.3	95.3	97.3
Raccourci	2010-13	94.4	93.9	94.9
Poverty	2010-12	94.4	88.8	99.9
Larto/Saline	2009-12	92.8	91.8	93.7
D'Arbonne	2009-12	88.9	87.9	89.9
Vernon	2009-11	79.8	77.9	81.6

Preferred Size

Waterbody	Years	Wr	L95%CI	U95%CI
Caddo	2011-13	101.6	99.8	103.4
Poverty	2010-12	99.9	92.3	107.5
Toledo	2009-11	98.3	97.8	98.8
Cross	2010-12	98.3	97.3	99.2
Larto/Saline	2009-12	94.5	93.2	95.8
Raccourci	2010-13	94.4	93.7	95.1
D'Arbonne	2009-12	88.7	87.6	89.8
Vernon	2009-11	78.8	75.0	82.7

Memorable Size

Waterbody	Years	Wr	L95%CI	U95%CI
Caddo	2011-13	98.5	95.3	101.7
Toledo	2009-11	97.3	96.0	98.6
Poverty	2010-12	96.7	NA	NA
Cross	2010-12	96.0	88.9	103.1
Larto/Saline	2009-12	93.9	89.7	98.0
D'Arbonne	2009-12	92.7	88.1	97.3
Raccourci	2010-13	91.6	90.3	92.9
Vernon	2009-11	NA	NA	NA

Trophy Size

Waterbody	Years	Wr	L95%CI	U95%CI
Cross	2010-12	NA	NA	NA
Poverty	2010-12	NA	NA	NA
Toledo	2009-11	NA	NA	NA
Vernon	2009-11	NA	NA	NA
D'Arbonne	2009-12	NA	NA	NA
Caddo	2011-13	NA	NA	NA
Larto/Saline	2009-12	NA	NA	NA
Raccourci	2010-13	NA	NA	NA

Table 6: Mean relative weights (W_r) of quality, preferred, memorable, and trophy size **white crappie**. Upper and lower 95% confidence intervals (CI), and years of lead net collections are also presented. Mean relative weights are sorted from highest to lowest with Vernon Lake results highlighted. *NA* indicates that insufficient numbers of fish were collected to generate an estimate.

Quality Size

Waterbody	Years	Wr	L95%CI	U95%CI
Poverty	2010-12	105.7	104.6	106.8
Caddo	2011-13	105.0	103.6	106.4
Cross	2010-12	102.3	101.4	103.2
Larto/Saline	2009-12	101.1	99.5	102.7
Toledo	2009-11	96.1	94.9	97.2
D'Arbonne	2009-12	90.5	89.5	91.6
Raccourci	2010-13	83.3	80.6	86.0
Vernon	2009-11	76.2	75.4	77.0

Preferred Size

Waterbody	Years	Wr	L95%CI	U95%CI
Poverty	2010-12	108.3	107.5	109.2
Caddo	2011-13	106.5	105.7	107.3
Cross	2010-12	104.4	102.9	105.8
Larto/Saline	2009-12	97.7	95.5	100.0
Toledo	2009-11	96.6	94.8	98.3
D'Arbonne	2009-12	93.7	92.5	94.9
Raccourci	2010-13	90.1	87.9	92.4
Vernon	2009-11	75.1	73.9	76.4

Memorable Size

Waterbody	Years	Wr	L95%CI	U95%CI
Poverty	2010-12	111.3	109.7	112.9
Caddo	2011-13	102.9	101.8	104.0
Cross	2010-12	98.0	95.9	100.1
Toledo	2009-11	93.6	88.8	98.4
Larto/Saline	2009-12	92.6	89.1	96.1
D'Arbonne	2009-12	90.2	88.0	92.4
Raccourci	2010-13	85.3	81.9	88.7
Vernon	2009-11	73.5	71.8	75.1

Trophy Size

Waterbody	Years	Wr	L95%CI	U95%CI
Caddo	2011-13	100.5	98.8	102.2
Cross	2010-12	96.0	83.9	108.0
Toledo	2009-11	84.0	76.7	91.3
Larto/Saline	2009-12	83.5	-7.3	174.3
Poverty	2010-12	NA	NA	NA
Vernon	2009-11	NA	NA	NA
D'Arbonne	2009-12	NA	NA	NA
Raccourci	2010-13	NA	NA	NA

Recruitment: Annual mean age-1 crappie lead net catch per unit effort (CPUE) in Vernon Lake compared to mean age-1 catch rates across all project lakes are shown Figure 4. Coefficients of variation describing the magnitude of variation in annual mean age-1 catch rates for waterbodies included in this project are presented in Table 7. This table illustrates variation in inter-annual recruitment among LA crappie populations.

Figure 4: Annual mean age-1 crappie catch rates from Vernon Lake fall lead net surveys (2009-2011) compared to mean age-1 catch rates across all project lakes. Catch per unit effort (CPUE) is defined as lead net catch per hour.

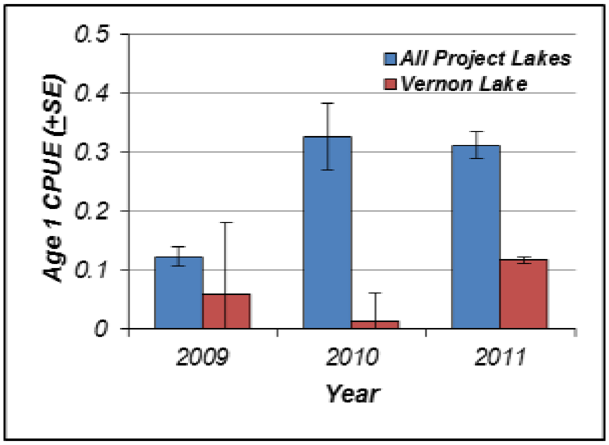

Table 7: Coefficients of variation (CV) describing the magnitude of variation in annual mean age-1 crappie catch per unit effort (CPUE) for Vernon Lake crappie fall lead net surveys (2009-2011). CPUE is defined as lead net catch per hour. Also presented are years of crappie lead net surveys. Coefficients of variation are sorted from lowest to highest with Vernon Lake results highlighted.

Waterbody	Years	CV
D'Arbonne	2009-12	43
Toledo Bend	2009-10	54
Cross	2010-12	62
Larto/Saline	2009-12	68
Poverty	2010-12	75
Vernon	2009-11	82
Caddo	2011-13	85
Raccourci	2010-13	129

Mortality: Total catch at age, mean CPUE at age, and corresponding 95% confidence intervals for the Vernon Lake fall lead net survey are presented in Table 8. The shaded area identifies ages included in the catch curve analysis. Age-1 catches were considered not fully recruited to LDWF lead net sampling gear and excluded from model fitting.

Table 8: Total catch at age, and mean catch per unit effort (CPUE) at age for Vernon Lake crappie fall lead net surveys (2009-2011). CPUE is defined as lead net catch per hour. Shaded area represents ages included in the catch curve analysis.

Age	Catch	CPUE	L95%CI	U95%CI
0	0	0.000	0.000	0.000
1	134	0.063	0.027	0.099
2	452	0.188	0.113	0.262
3	125	0.056	0.036	0.076
4	68	0.035	0.017	0.052
5	16	0.006	0.004	0.009
6	3	0.001	0.000	0.002
7	0	0.000	0.000	0.000
8	1	0.000	0.000	0.001

Observed mean CPUE at age and observed and predicted log_eCPUE at age of crappie collected from Vernon Lake fall lead net surveys are presented in Figure 5.

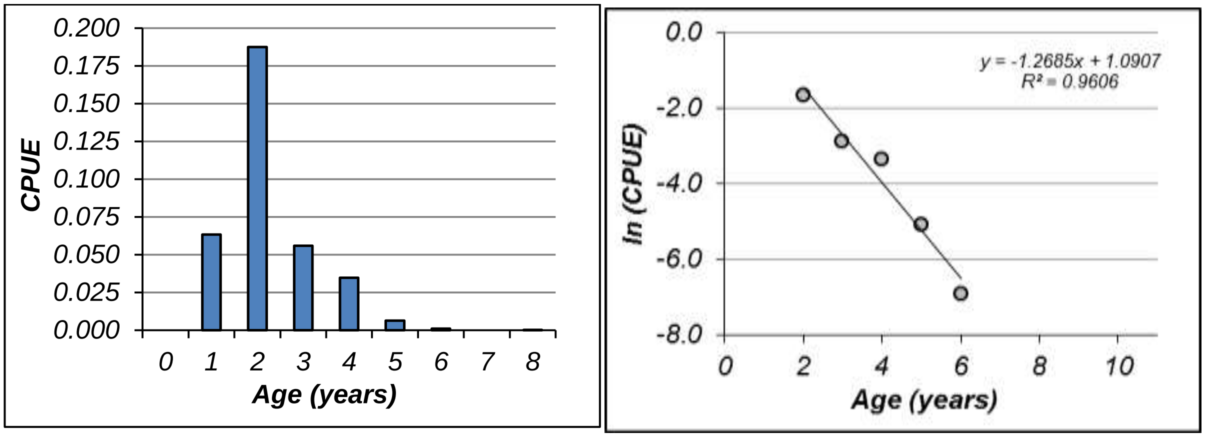

Figure 5: Observed mean catch rates by age of the Vernon Lake crappie fall lead net surveys (2009-2011; left graphic). Right graphic depicts observed (circles) and predicted (line) mean log_e CPUE by age. The catch curve equation and coefficient of determination (R^2) are presented in graphic. Catch per unit effort (CPUE) is defined as lead net catch per hour.

Total instantaneous and interval mortality rate estimates for crappie populations included in this project are presented in Table 9. This table illustrates variation in total mortality rate estimates among LA crappie populations.

Table 9: Total instantaneous (Z) and interval (A) mortality rates for waterbodies included in this project, ages included in each catch curve, 95% confidence intervals, years of lead net collections, and current size limit regulations. Estimates are sorted from highest to lowest with Vernon Lake results highlighted. For *Regulation*, LL = length limit, CL = creel limit.

Waterbody	Years	Ages	Regulation	Z	L95%CI	U95%CI	A	L95%CI	U95%CI
Poverty	2010-12	1-3	No LL, 25 CL	-2.62	-4.21	-1.03	0.93	0.64	0.99
Larto/Saline	2009-12	2-5	No LL, 50 CL	-1.68	-2.30	-1.06	0.81	0.65	0.90
D'Arbonne	2009-12	2-5	No LL, 50 CL	-1.47	-2.53	-0.40	0.77	0.33	0.92
Toledo Bend	2009-11	2-6	No LL, 25 CL	-1.42	-1.74	-1.10	0.76	0.67	0.82
Cross	2010-12	2-5	No LL, 50 CL	-1.39	-2.10	-0.67	0.75	0.49	0.88
Vernon	2009-11	2-6	No LL, 50 CL	-1.27	-1.74	-0.80	0.72	0.55	0.82
Raccourci	2010-13	2-7	No LL, 50 CL	-0.95	-1.07	-0.85	0.61	0.57	0.66
Caddo	2011-13	2-8	No LL, 25 CL	-0.47	-0.64	-0.31	0.38	0.26	0.47

Maximum observed age of crappie populations included in this project and assumed longevities used in the low, medium, and high natural mortality scenarios are presented in Table 10.

Table 10: Maximum observed age of crappie and assumed maximum ages used for each natural mortality scenario for waterbodies included in this project. Also inlcuded are the years of lead net collections. Maximum observed ages are sorted from highest to lowest with Vernon Lake results highlighted.

		Age_max			
			Natural Mortality Scenario		
Waterbody	Years	Observed	Low	Medium	High
Toledo Bend	2009-10	9	12	11	10
Cross	2010-12	9	12	11	10
Vernon	2009-11	8	11	10	9
Caddo	2011-13	8	11	10	9
Raccourci	2010-13	8	11	10	9
Larto/Saline	2009-12	7	10	9	8
D'Arbonne	2009-12	6	9	8	7
Poverty	2010-12	4	7	6	5

Natural and fishing mortality rate estimates for each natural mortality scenario are presented in Tables 11 and 12, respectively. These tables illustrate variation in natural and fishing mortality rate estimates among LA crappie populations.

Table 11: Instantaneous and interval crappie natural mortality rate estimates ($M$and v, respectively) by natural mortality scenario

and waterbody, ages included in each catch curve, years of lead net collections, and current size limit regulations. Estimates are sorted from highest to lowest with Vernon Lake results highlighted. For *Regulation*, LL = length limit, CL = creel limit.

				Natural Mortality Scenario					
				Low		Medium		High	
Waterbody	Years	Ages	Regulation	M	v	M	v	M	v
Poverty	2010-12	1-3	No LL, 25 CL	-0.60	0.21	-0.70	0.25	-0.84	0.30
D'Arbonne	2009-12	2-5	No LL, 50 CL	-0.47	0.25	-0.53	0.28	-0.60	0.32
Larto/Saline	2009-12	2-5	No LL, 50 CL	-0.42	0.20	-0.47	0.23	-0.53	0.26
Cross	2010-12	2-5	No LL, 50 CL	-0.35	0.19	-0.38	0.21	-0.42	0.23
Vernon	2009-11	2-6	No LL, 50 CL	-0.38	0.22	-0.42	0.24	-0.47	0.27
Raccourci	2010-13	2-7	No LL, 50 CL	-0.38	0.25	-0.42	0.27	-0.47	0.30
Caddo	2011-13	2-8	No LL, 25 CL	-0.38	0.31	-0.42	0.34	-0.47	0.37
Toledo Bend	2009-11	2-6	No LL, 25 CL	-0.35	0.19	-0.38	0.20	-0.42	0.23

Table 12: Instantaneous and interval crappie fishing mortality rate estimates ($F$and u, respectively) by natural mortality scenario and waterbody, ages included in each catch curve, years of lead net collections, and current size limit regulations. Estimates are sorted from highest to lowest with Vernon Lake results highlighted. For *Regulation*, LL = length limit, CL = creel limit.

				Natural Mortality Scenario					
				Low		Medium		High	
Waterbody	Years	Ages	Regulation	F	u	F	u	F	u
Poverty	2010-12	1-3	No LL, 25 CL	-2.01	0.71	-1.91	0.68	-1.77	0.63
Larto/Saline	2009-12	2-5	No LL, 50 CL	-1.26	0.61	-1.21	0.59	-1.15	0.56
Toledo Bend	2009-11	2-5	No LL, 50 CL	-1.07	0.57	-1.04	0.55	-1.00	0.53
Cross	2010-12	2-6	No LL, 25 CL	-1.04	0.56	-1.00	0.54	-0.97	0.52
D'Arbonne	2009-12	2-5	No LL, 50 CL	-1.00	0.52	-0.94	0.49	-0.86	0.45
Vernon	2009-11	2-6	No LL, 50 CL	-0.88	0.50	-0.85	0.48	-0.80	0.45
Raccourci	2010-13	2-7	No LL, 50 CL	-0.57	0.37	-0.53	0.34	-0.48	0.31
Caddo	2011-13	2-8	No LL, 25 CL	-0.09	0.07	-0.05	0.04	0.00	0.00

Fishery Characteristics:

An LDWF creel survey was conducted on Vernon Lake from January through December 2010. Estimates of mean crappie harvest rates per trip by month for waterbodies included in this project are provided in Table 13. No creel survey was conducted on Old River Raccourci or the Larto/Saline Complex. Crappie harvest rates and frequency by trip were not available for the Toledo Bend Reservoir creel survey. Frequencies of crappie harvested per angler-trip for Vernon Lake are provided in Figure 6. Estimates represent crappie anglers only. A comparison of total crappie catch by species between the lead net and creel surveys is found in Table 14.

Table 13: Mean crappie harvest per trip by month for waterbodies included in this project. The year that the creel survey was conducted is indicated. Vernon Lake results are highlighted.

	Crappie Harvest per Trip				
Waterbody	Cross	Caddo	Poverty	Vernon	D'Arbonne
Month/Year	2010	2011	2012	2010	2011
January	1.8	0.0	3.2	0.5	1.4
February	1.6	0.4	2.6	0.0	2.7
March	1.4	3.8	4.2	0.0	0.2
April	3.6	0.0		0.5	1.9
May	17.6	1.3		0.0	1.3
June		4.3	0.0	5.8	0.6
July		4.7		4.3	5.0
August	0.0			5.0	1.0
September	2.3	8.0	3.3	1.5	0.2
October	3.1	8.7	2.2	4.0	3.5
November	2.0	3.5	4.3		5.1
December	1.2	0.1			2.6
Average	3.5	3.2	2.8	2.2	2.1

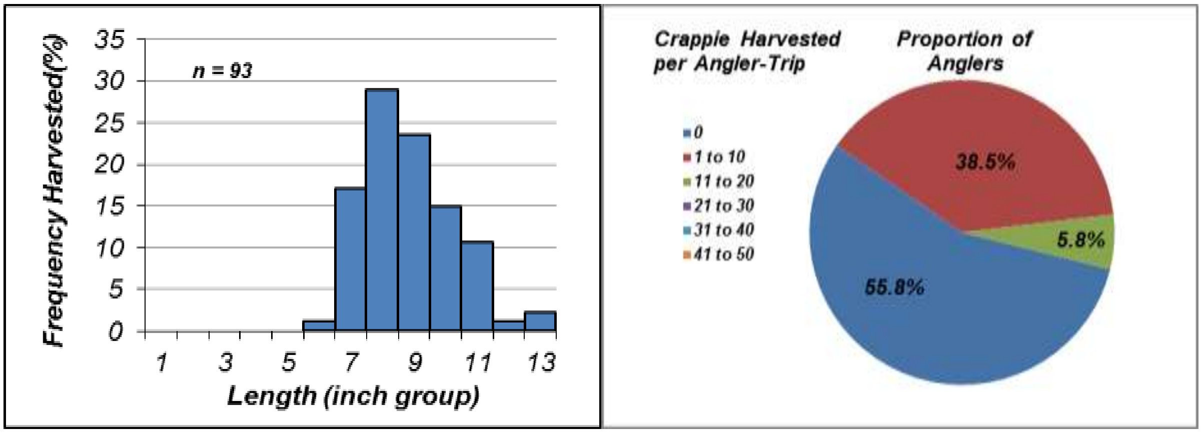

Figure 6: Frequencies of crappie harvested by inch group and per angler-trip for Vernon Lake crappie anglers derived from the creel survey conducted in 2010. There were no anglers interviewed that harvested over 20 crappie.

Table 14: The contribution of black crappie and white crappie to total crappie catch compared between lead net and creel surveys. Vernon Lake results are highlighted.

		Black Crappie		White Crappie	
Waterbody	Year	Lead Net	Creel	Lead Net	Creel
Cross (2010)	2010	520 (72%)	71 (54%)	200 (28%)	61 (46%)
Caddo (2011)	2011	351 (64%)	293 (77%)	196 (36%)	89 (23%)
D'Arbonne (2011)	2011	41 (24%)	256 (35%)	127 (76%)	470 (65%)
Poverty (2012)	2012	3 (1%)	29 (4%)	261 (99%)	666 (96%)
Vernon (2010)	2010	25 (21%)	6 (6%)	92 (79%)	87 (94%)

Population Simulations:

Parameter values used in the Vernon Lake crappie age and sex structured simulation model are presented in Table 15.

Table 15: Parameter values used in the Vernon Lake age and sex structured crappie population simulations.

Parameter	Description	Values
	Low Natural Mortality Scenario	
Age_max	Longevity (years)	11
M	Instantaneous natural mortality rate (years^{-1})	0.38
F	Instantaneous fishing mortality rate (years^{-1})	0.88
	Medium Natural Mortality Scenario	
Age_max	Longevity (years)	10
M	Instantaneous natural mortality rate (years^{-1})	0.42
F	Instantaneous fishing mortality rate (years^{-1})	0.85
	High Natural Mortality Scenario	
Age_max	Longevity (years)	9
M	Instantaneous natural mortality rate (years^{-1})	0.47
F	Instantaneous fishing mortality rate (years^{-1})	0.80
	All Scenarios	
d	Discard mortality rate (proportion not surviving)	0.1
R	Constant recruitment	10000
Lvul	Length at recruitment to fishery (inches)	7.0
Linf_female	Female asymptotic average maximum length	15.07
K_female	Female von Bertalanffy growth coefficient	0.32
t0_female	Female von Bertalanffy time at zero TL	0.00
a_female	Female length-weight constant	7.94E-0.06
b_female	Female length-weight allometric parameter	3.06
Linf_male	Male asymptotic average maximum length	12.55
K_male	Male von Bertalanffy growth coefficient	0.48
t0_male	Male von Bertalanffy time at zero TL	0.00
a_male	Male length-weight constant	7.52E-0.06
b_male	Male length-weight allometric parameter	3.08

Simulation results illustrating the effect of two size regulations (10 and 12 inch minimum length limits) on total catch and catch per angler-trip relative to the current regulation (no length limit) for the three natural mortality scenarios are presented in Figures 7 and 8. The percent of crappie caught that would need to be released due to size regulations under each mortality scenario is shown in Figure 9. Simulation results illustrating the effects of size regulation implementation on mean weight of harvested crappie, the number of crappie harvested per trip, and yield relative to the "no length limit" regulation for three different natural mortality scenarios are presented in Figures 10, 11, and 12. Figure 13 illustrates the effect of each simulated size regulation on yield as a function of instantaneous fishing mortality for each natural mortality scenario.

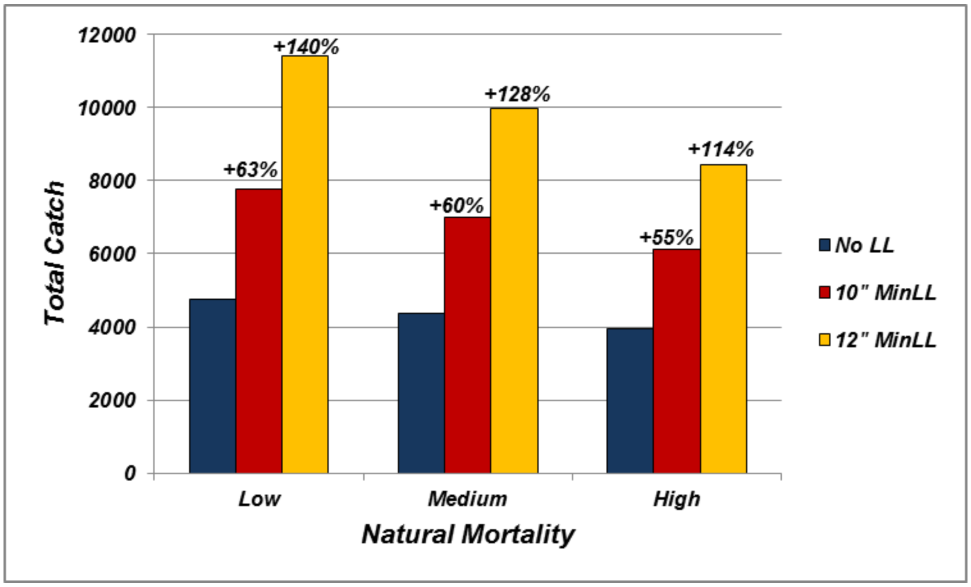

Figure 7: Model results illustrating the effect of two simulated size regulations (10 and 12 inch minimum length limits) on Vernon Lake crappie total catch (numbers of fish), relative to the current regulation (no length limit) for three natural mortality scenarios. Units are relative to constant recruitment of 10,000 individuals.

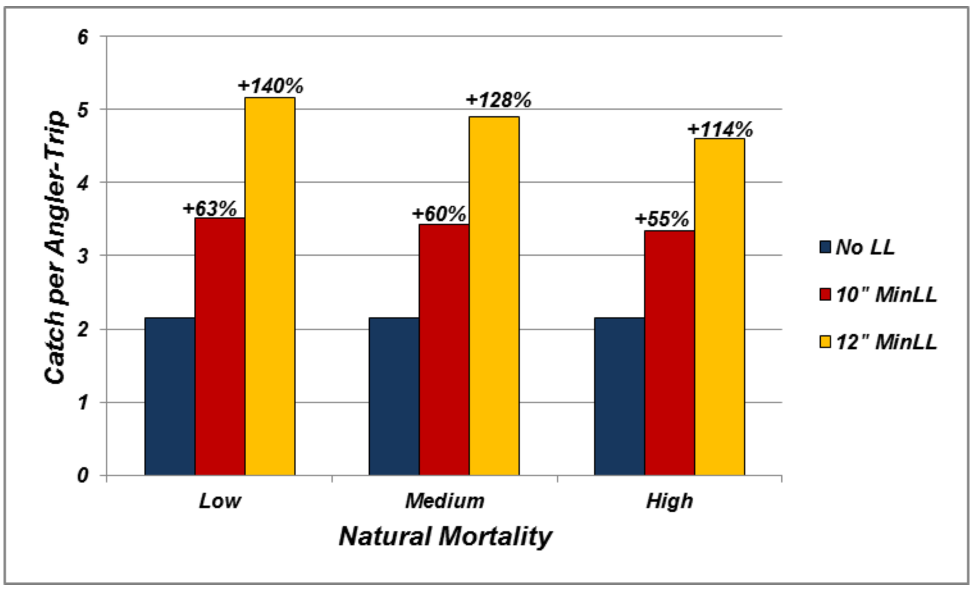

Figure 8: Model results illustrating the effect of two simulated size regulations (10 and 12 inch minimum length limits) on the mean number of crappie caught per angler-trip relative to the current regulation (no length limit) for three natural mortality scenarios in Vernon Lake. Baseline (no length limit) trip harvest rates were taken from the Vernon Lake creel survey in 2011.

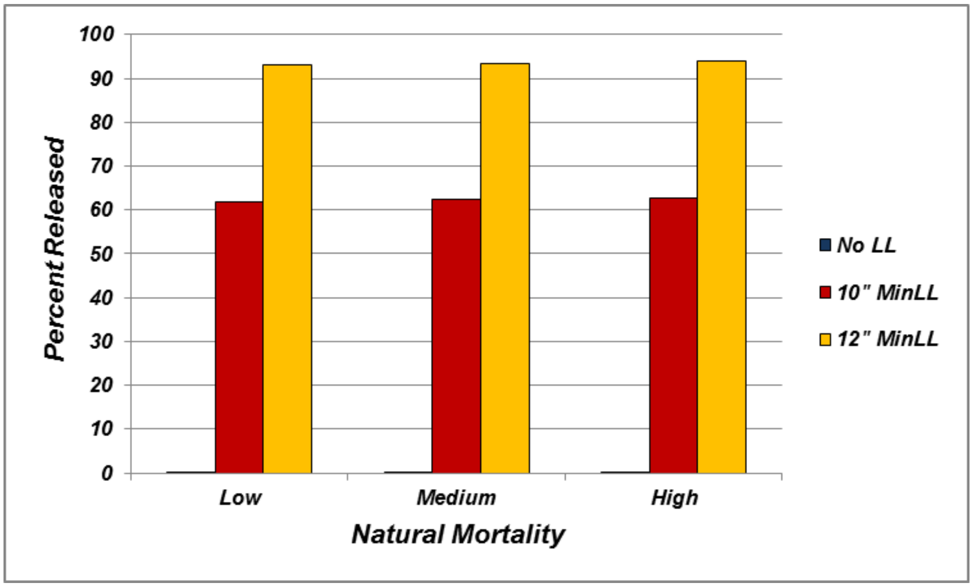

Figure 9: Model results illustrating the effect of two simulated size regulations (10 and 12 inch minimum length limits) on the number of crappie that would need to be released due to size regulations relative to the current regulation (no length limit) for three natural mortality scenarios in Vernon Lake. We assumed zero fish are released for the "no length limit" regulation.

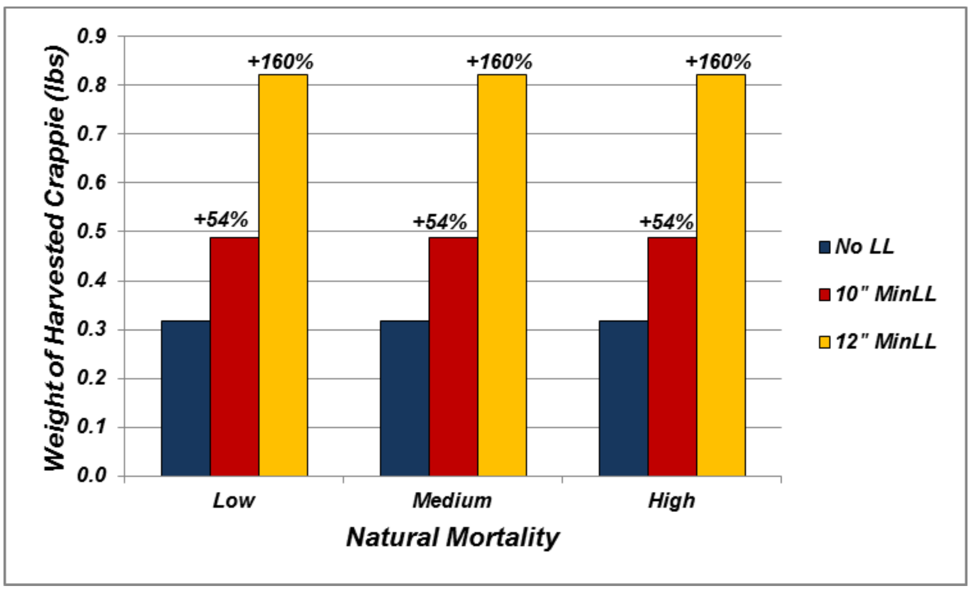

Figure 10: Model results illustrating the effect of two simulated size regulations (10 and 12 inch minimum length limits) on the mean weight of harvested crappie relative to the current regulation (no length limit) for three natural mortality scenarios in Vernon Lake.

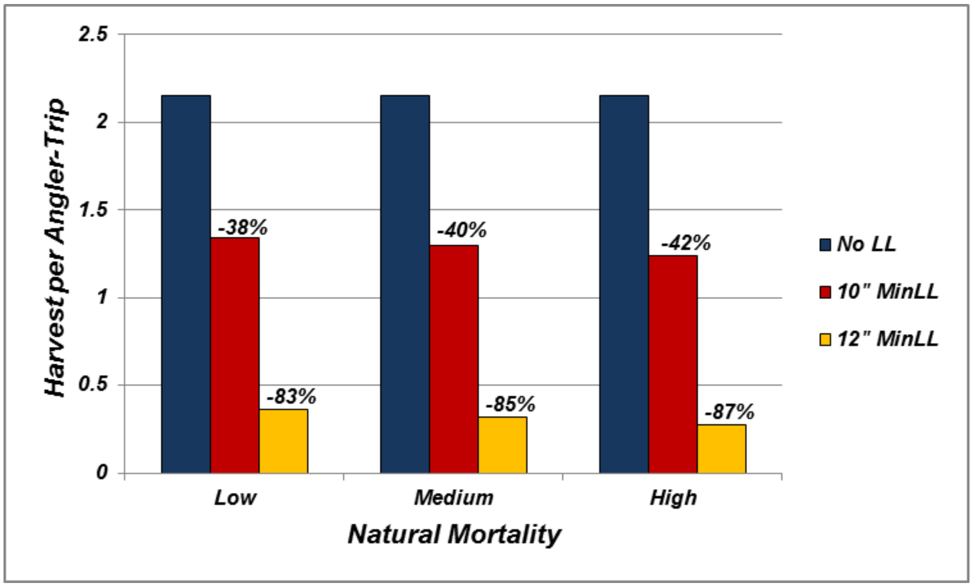

Figure 11: Model results illustrating the effect of two simulated size regulations (10 and 12 inch minimum length limits) on the mean number of crappie harvested per angler-trip relative to the current regulation (no length limit) for three natural mortality scenarios in Vernon Lake. Baseline (no length limit) trip harvest rates were taken from the Vernon Lake creel survey in 2011.

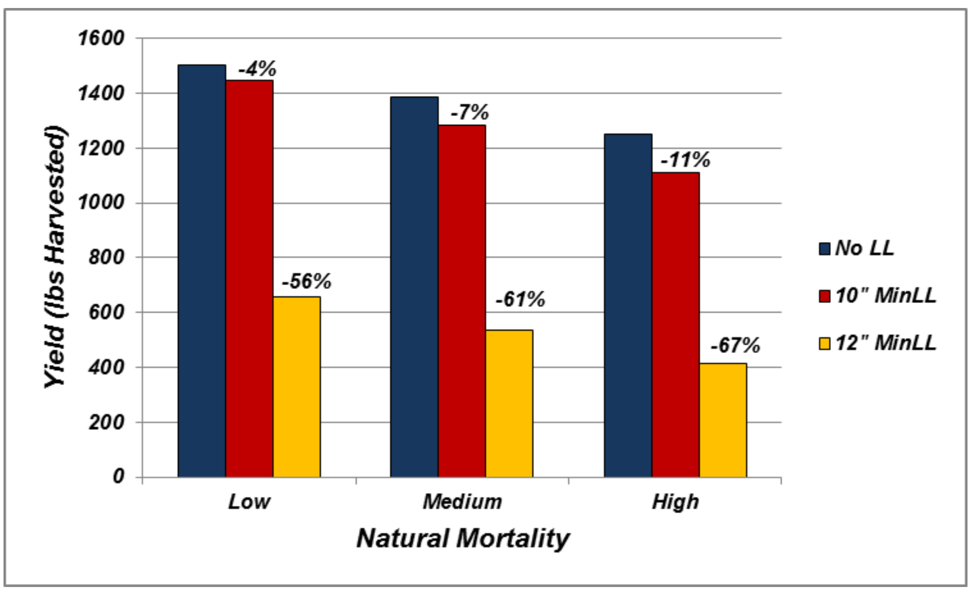

Figure 12: Model results illustrating the effect of two simulated size regulations (10 and 12 inch minimum length limits) on Vernon Lake crappie yield (pounds harvested), relative to the current regulation (no length limit) for three natural mortality scenarios. Units are relative to constant recruitment of 10,000 individuals.

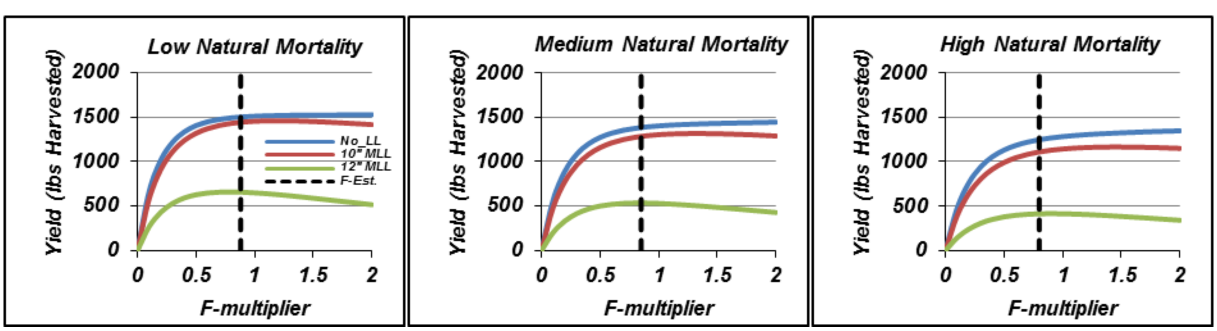

Figure 13: Model results illustrating the effect of three simulated size regulations (no length limit, 10 and 12 inch minimum length limits) on Vernon Lake crappie yield (pounds harvested) versus instantaneous fishing mortality (*F*) for three natural mortality scenarios. Also shown is the estimate of *F* associated with each natural mortality scenario. Units are relative to constant recruitment of 10,000 individuals.

Discussion:

Population Characteristics:

Species Composition: White crappie was the dominant crappie species observed from 2009-2011; however, the proportion of black crappie increased throughout the study (Table 1).

Growth: The Vernon Lake crappie population has the slowest growth rate observed for the waterbodies included in this project (Table 3). The time in years to reach quality (8 inch TL), preferred (10 inch TL), and memorable (12 inch TL) sizes for the Vernon Lake crappie population (2.3, 3.3, and 4.9 years, respectively) are much higher than the population exhibiting the fastest time to size (Poverty Point Reservoir; 0.8, 1.3, and 2.2 years respectively). The Larto/Saline Lake crappie population has the most similar growth rate (i.e., 2.0, 3.0, and 4.5 years respectively) when compared to the Vernon Lake crappie population.

The method of von Bertalanffy model fitting used in this assessment assumed that the data are representative samples of lengths from each age-class. If this assumption fails (e.g., size-selective sampling and cumulative effects of fishing mortality), model parameters can only describe the current population available to harvest (Taylor et al. 2005). In other words, the current VBGF fitting methodology may underestimate growth when faster growing individuals are removed from the population disproportionaly due to size-selective fishing mortality. If determining potential growth rates under a no harvest scenario is of interest, then the methodology detailed in Taylor et al. (2005) could be used in future analyses.

Size Structure Indices: The Vernon Lake crappie PSD indices are moderate compared to the other populations included in this project (Table 4). The Vernon Lake PSD index for fish larger than quality size (PSD-Q; 65) is less than the highest estimate (Poverty Point Reservoir; 82). The Vernon Lake PSD index for fish larger than preferred size (PSD-P; 27) is also less than the highest estimate (Poverty Point Reservoir; 55). Caddo Lake had the highest PSD index for fish larger than memorable size (PSD-M; 22), which was substantially higher that the Vernon Lake estimate (8.8). The Cross Lake and Vernon Lake crappie populations had nearly identical PSD indices.

Optimum ranges of PSD indices have been proposed for maintaining balanced crappie populations (Neumann et al. 2012). Vernon Lake estimates for quality and preferred sized crappie (PSD-Q = 65, PSD-P = 27) are above the recommended ranges (PSD-Q: 30-60, PSD-P: >10). Indices falling outside these ranges may indicate unstable crappie recruitment, growth, and mortality, or that population density is above optimum levels.

An important assumption in obtaining unbiased estimates of PSD indices is that samples are representative of the standing crappie population size structure. If this assumption fails, estimates will be biased low. This is an important limitation not only for unbiased estimates of population size structure, but also for obtaining accurate estimates of age-specific relative abundance and subsequent estimates of total mortality.

Condition: Tables 5 and 6 present species and size-specific mean relative weight estimates for waterbodies included in this project. For both black crappie and white crappie, Vernon Lake mean W_r estimates of quality, preferred, and memorable sized fish are well below the recommended range (95-105) of a balanced population (Neumann et al. 2012). Mean relative weights of Vernon Lake crappie were the lowest observed when compared with estimates of other project waterbodies, and most similar to Old River Raccourci estimates overall. Mean W_r estimates well below 100 may indicate a problem with prey availability or feeding conditions (Neumann et al. 2012).

Recruitment: Annual age-1 CPUE of Vernon Lake crappie was consistently lower than the state-wide average (Figure 4), and recruitment variability (CV=83) was slightly higher than other waterbodies included in this project. The Old River Raccourci population exhibited the largest variability in recruitment (CV=130). Bayou D'Arbonne Lake crappie recruitment is the least variable (CV=44) of all the waterbodies included in this project. The next lowest recruitment variability in annual age-1 CPUE estimates was for Toledo Bend Reservoir (CV=55).

Via simulation analysis, Allen and Pine (2000) demonstrate that crappie population responses to length limit implementation are often obscured by variable recruitment. Their results suggest that populations with above average recruitment variability may not have detectable responses to length limit implementation, unless the regulation change is significant. Vernon Lake inter-annual recruitment variability was low compared to the other populations included in this study; however, each population's coefficient of variation was estimated with only three or four years of data. Future analyses incorporating annual age-1 CPUE data over a longer time-series will allow a more accurate assessment of recruitment in and among LA crappie populations.

Mortality: The Vernon Lake crappie population had the third lowest estimate of total mortality (Z=-1.27/year; A=0.77/year) when compared to the other populations included in this project (Table 9). The lowest total mortality rate (Z=-0.72/year; A=0.38/year) was estimated for the Caddo Lake crappie population; the highest estimate (Z=-2.62/year; A=0.93/year) was for the Poverty Point Reservoir crappie population. The mortality estimates for Toledo Bend Reservoir, Caddo Lake, and Bayou D'Arbonne Lake represent transitional periods in each fishery due to crappie harvest regulation changes during the timeframe of this study.

To obtain unbiased estimates of total mortality rates via catch curve analysis, three assumptions must be met: 1) mortality is constant across ages, 2) recruitment is constant, and 3) samples are representative of the true age structure in the population. The first two assumptions are rarely met, and the impact of the second assumption is lessened in this assessment as described in *Methods*. If the third assumption of representative sampling is not met, mortality rate estimates will be biased.

The Vernon Lake crappie population has an observed maximum age of 8 years, which was the most frequently observed maximum age across waterbodies (Table 10). The Toledo Bend and Cross Lake populations had the oldest age observed (9 years). The Poverty Point Reservoir population has the lowest observed maximum age (4 years). Given the approximation of M from equation [8], crappie populations with low maximum observed ages correspond to higher estimates of M; populations with high maximum observed ages correspond to lower estimates of M. Since exploitation of crappie populations is likely high, we developed multiple natural mortality scenarios to explicitly demonstrate uncertainty in M (see *Methods: Population Characteristics: Mortality* section, and Tables 10 and 11).

The Vernon Lake crappie population had a moderately low fishing mortality rate for each natural mortality scenario when compared to other crappie populations included in this project (Table 12). The lowest fishing mortality rate estimates were for the Caddo Lake crappie population, and the highest estimates were for the Poverty Point Reservoir crappie population (Table 12). Fishing mortality rate estimates presented in this report are approximated by difference (i.e. $Z - M$). If approximation of M from equation [8] is uncertain, fishing mortality estimates would also be considered uncertain.

Fishery Characteristics:

The annual estimate of mean crappie harvest per trip from the Vernon Lake fishery was 2.2, which was the second lowest harvest rate observed (Table 12). The highest estimate was for the Cross Lake fishery (3.5). In Vernon Lake, peak crappie harvest occurred in June and august. Most crappie harvested were in the 8 inch length group (22.5%, Figure 6). Harvest rates are heavily influenced by a large number of crappie anglers who harvested zero crappie (Vernon Lake = 56%, Figure 6). For the five lakes where creel surveys were completed, 95% of anglers harvested less than 10 crappie. If creel survey results are representative of the fishery, creel limits would have to be substantially lowered in order to have an impact on the population. Table 13 shows that the proportions of black and white crappie sampled during the lead net surveys are similar to the proportions harvested by crappie anglers.

Population Simulations:

Population simulations presented in this report are based on equilibrium conditions (i.e., long-term averages) and do not include more complex dynamics such as recruitment variability, density dependent growth, and environmental conditions.

Implementation of a minimum length limit on Vernon Lake crappie would result in increased total catch (Figure 7) and catch per angler-trip (Figure 8), but would increase the number of crappie that would need to be released (Figure 9). These effects increase as the minimum size limit increases, but are less pronounced with higher natural mortality scenarios. Length limit implementation would also increase the mean weight of crappie harvested (Figure 10), however the lower number of crappie harvested per angler-trip (Figure 11) would result in decreased overall yield (Figure 12). These effects increase as the minimum size limit increases and are more pronounced with higher natural mortality. Figure 13 demonstrates that if natural mortality remains constant, there is no level of fishing mortality that would result in higher yields after implementing a minimum length limit.

Allen and Miranda (1995) suggest that two conditions are required in order for minimum length limits to increase crappie yield: instantaneous natural mortality below 0.35-0.50 and fast growth rates. The estimates of M calculated for each scenario of this study are within this range (low = 0.38, medium = 0.42, high = 0.47). The Vernon Lake crappie growth rate was the slowest observed, but is similar to the “fast growth” scenario used in Allen and Miranda (1995), which was derived from northern crappie populations. Lower natural mortalities and/or faster growth rates may be necessary to improve yield using a 10 inch minimum length limit in Vernon Lake. The results in this report are similar to those reported in Maceina et al. (1998), who concluded that for an Alabama crappie population, a 10 inch minimum length limit would increase yield if natural mortality was reduced.

For the waterbodies included in this project, only the Toledo Bend Reservoir and Cross Lake crappie populations demonstrated natural mortalities and growth rates that produced greater simulated yields with a 10 inch minimum length limit versus no length limit. Caddo Lake had similar natural mortalities and growth rates as Toledo Bend Reservoir and Cross Lake, but simulations did not indicate minimum length limits would improve yield. This is due to extremely low F estimates resulting in extremely low yields. This illustrates the importance of F in determining whether a crappie fishery would benefit from length limits.

Conclusions:

It is important to note that crappie populations and their fisheries are not only influenced by fishing effort, but also by anthropogenic and environmental factors. The type and degree of human activity within watersheds, riparian zones, and specific waterbodies can affect crappie populations by altering critical habitats. Additional factors influencing crappie populations include aquatic vegetation coverage, water level management, and habitat improvements. The frequency of floods, drought, and hurricanes can also influence crappie populations. While consideration of these factors is important in effective fisheries management, evaluating how these factors affect the Vernon Lake crappie population and fishery is beyond the scope of this report.

The Vernon Lake crappie population has a moderate maximum age, slow growth rate, moderate mortality rate, with moderate recruitment variability when compared with the other crappie populations included in this project. The Vernon Lake crappie fishery is currently managed with no size restrictions and a 50 fish per day harvest limit. Given the dynamics of the Vernon Lake crappie population and fishery, creel limits would have to be substantially lowered in order to have any effect on the population. Size limit implementation would likely decrease yield and substantially increase the numbers of crappie that would need to be released by anglers.

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APPENDIX IV

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